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DEVOTED TO

SCIENCE AND THE MECHANIC ARTS

PROGRESS

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PANORAMA

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PROGRESS

HONORING

BENJAMIN FRANKLIN

1706–1956

PREFACE

During 1956, the civilized world is celebrating the 250th anniversary of the birth of Benjamin Franklin. It is some measure of the stature of the man to realize that young and old, of diverse religious faiths, of widely differing economic and social backgrounds, and from many nations, are aware of his contributions to civilization. Here is a man, born and bred in 18th century America, whose philosophy has appealed to generations of people in many lands, and whose penetrating observations and recommendations on science, economics, social welfare and international relations are still valid after two centuries.

It is not easy to say something new about Franklin, for his own prolific writings and his many biographies have provided an almost complete story of the man and his works. Few historical figures are so well delineated in the minds of so many.

Therefore, when the Editors of this JOURNAL, published by the Institute which bears Franklin's name, were confronted with the problem of honoring their patron saint's 250th anniversary, a new approach was called for—one which would be useful in the Franklin tradition, which would emphasize better international relations in accordance with the over-all Celebration plan, and yet which would not deviate too far from the JOURNAL's policy of promoting scientific and technical information.

We believe the plan we have followed has fulfilled these aims.

In this age of highly specialized techniques, it is difficult for even the specialists to keep abreast of developments in their own specialties; it is even more of a task for scientists in one field to acquaint themselves with the work of their colleagues in a different field. The layman, confounded by technical words he does not comprehend, too often surrenders all hope of understanding what the scientists are doing to him and for him, and apathetically accepts changes as they occur.

The papers in this issue are planned to give a broad picture of the advances made in the physical sciences (both pure and applied), in the social sciences and in economics, since the time when Franklin was born. They are written in a language which the layman can understand; but we believe scientists also will find the papers of interest as a panoramic view of the past 250 years, which have witnessed almost the entire span of modern science.

The papers are rendered more valuable, in that their authors are distinguished representatives of the most revered scientific societies in the world. The Societies and organizations represented herein either honored Franklin with membership, or were founded by him or in his name. The editors are grateful to these Societies and to their representatives for ac-

cepting our invitation to prepare papers for this anniversary volume. Their contributions not only highlight the incredible progress man has made in the physical and social sciences since the beginning of the 18th century, but they also emphasize, both directly and indirectly, the very real progress toward that day when the peoples of all nations shall recognize the truth of these words of Franklin:

> We must, indeed, all hang together, or most assuredly we shall all hang separately.

and

> To make a Peace durable, what may give Occasion for future Wars should, if practicable, be removed.

HENRY B. ALLEN
Editor

December 1, 1955.

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A PROGRAM
POOR RICHARD WOULD HAVE LOVED

Being a Summary of a few of the highlights of the International Celebration

BY

C. L. JORDAN [1]

250th Anniversary Committee

Benjamin Franklin believed that the free and voluntary communication of ideas was man's greatest service to man. Without such communication, there could be no growing wisdom, understanding, peace or freedom.

Elbert Hubbard once wrote of him:

> His passion was to acquire knowledge—
> The desire of his heart was to communicate it.

This outstanding characteristic of Benjamin Franklin provided the Plan and Program for the International Celebration of the 250th Anniversary of his Birth.

More than 500 Societies, Associations and Institutions in many countries are cooperating. Each plans its own program, in its own traditional manner. Basic subjects are selected from the four fields in which Franklin made outstanding contributions:

SCIENCE ..... Man and Matter
SOCIOLOGY ..... Man and Society
ECONOMICS ..... Man and His Works
INTERNATIONAL RELATIONS . Man and His Ideals

Papers, addresses and news on these subjects will be mailed to about 5000 newspapers, magazines, radio and television stations in all cooperating countries. In this way, it is expected that many millions of people, in their own homes, in their own countries, may share in the exchange of ideas.

FRANKLIN'S OWN PLAN

This was the plan which Benjamin Franklin, himself, followed. He was honored by election to membership in 25 of the great Scientific and Educational Societies of his day. He and his associates wrote hundreds of papers and letters to be read and published through such groups. In turn, they sent their ideas to spread among the eager minds of Franklin's young country.

The effectiveness of this type of work was beyond calculation. Lord

[1] Chairman of the 250th Anniversary Committee of The Franklin Institute, Philadelphia, Pa., U.S.A.

Rayleigh, President of The Royal Society in 1906, said that if the work of Franklin and his associates had been permitted to continue, "the rise and rapid advance of American Science might have been antedated by a century."

A single example may illustrate the powerful effect of such exchanges on the development of one of the world's greatest blessings—Electricity.

Bern Dibner, in a fascinating series on the "Ten Founding Fathers of the Electrical Science"[2] named Dr. William Gilbert, England; Otto von Guericke, Prussia; Benjamin Franklin, America; Alessandro Volta, Italy; and André Marie Ampère, France, among the earliest. Here were five men, each in a different country, in an age of war, uneasy peace and poor communications, separated by nearly two centuries. Yet their ideas were shared through the great Scientific Societies, and the infant industry of Electricity took form and moved towards its destiny as mankind's most universal servant.

There is no brighter page in history than the free and voluntary exchange of information by these great Societies. A highlight of the Franklin Anniversary will be the award to them of a Franklin Medal for Distinguished Service by the Congress of the United States.

Nineteen of the 25 Societies are still in existence and are among those conducting the Celebration now—as are many of the world's Publishing and Broadcasting Associations, which are cooperating in memory of America's first great publisher.

A MODERN VERSION OF THIS PLAN

What Franklin and his contemporaries did in an age of limited communications is even more practical today with the modern miracles of publishing, broadcasting, telephony and motion pictures.

The exchange of ideas in 1956 will be accomplished by many public addresses, conventions, publications and broadcasting in all countries. Scientists, Educators, Editors, Business Men and Statesmen, representing the 500 cooperating groups, will tell of the improvements in standards of living, health and happiness that can be achieved through better international understanding:

They will speak of great new scientific inventions, now in the laboratories of all countries, and which could benefit the people more rapidly under better conditions of international cooperation.

Of the challenging future of atomic energy once it may be devoted to the service of man rather than his destruction.

Of the miraculous strides of medicine which might save many lives that are now lost needlessly.

Of the progress in agriculture which could help to meet the needs of rapidly growing populations, reduce the haunting fears of famine and release millions of people for the industrial expansions that would raise the living standards all over the world.

---

[2] *Electrical Engineering*, Vol. 73, Nos. 4-12 (1954) and Vol. 74, No. 1 (1955).

Of the spread of ideas by the freely printed and spoken word, which Franklin said was the basis of all freedom.

And of the philosophy of Franklin himself who tirelessly fought for respect and equality among all races, colors and creeds—to the end that, some day, there might be a deeper and more enduring kinship among mankind.

FREE AND VOLUNTARY EXCHANGE

This program was planned privately by individual groups interested in the traditions of Benjamin Franklin. The ideas advanced are not connected with the foreign policies of any Government—although many Governments will cooperate in the Celebration. The discussion is free and voluntary— after the manner of Poor Richard and his associates.

While every Sponsor plans its own program independently, many will cooperate on similar themes within the same fields of endeavor. This again, is in the tradition of Franklin, who wisely said:

> The ancient Roman and Greek orators could only speak to the numbers of citizens capable of being assembled within the reach of their voice. Their writings had little effect because the bulk of the people could not read. Now, by the press, we can speak to nations; and good books and well written pamphlets have great and general influence.
>
> The facility with which the same truths may be repeatedly enforced by placing them daily in different lights in different newspapers, which are everywhere read, gives a great chance of establishing them.
>
> —*Letter to Richard Price in 1782*

TEN FIELDS OF ENDEAVOR

In addition to the over-all objective of contributing to better international understanding, the program has been divided into ten sections—in each of which Benjamin Franklin served:

Section 1—Education and the Natural Sciences

A theme which many will emphasize in this section is the constant need for the development of more complete scholars like Franklin in this age of high specialization. Much of the fruit of progress, especially in international relations, may be lost by even the finest specialists who do not understand the humanities and the motivation of peoples.

Among the highlights are:

This Memorial issue of the JOURNAL OF THE FRANKLIN INSTITUTE—containing papers prepared by many of the old Societies of which Franklin was a member, from different countries and covering a wide range of man's activities.

Two featured publications: The Yale Press will publish a selection of Franklin's personal letters on an amazing variety of subjects. The Louisiana State University Press will publish "Franklin's Privateers."

Addresses and papers by leading Educators on the importance to the world of more scholars trained in the broad field of knowledge.

Libraries and Museums in many countries will have exhibits honoring the founder of America's first lending library and one of our first natural scientists.

Section 2—International Relations and the Public Service

The central theme of the Celebration is to contribute to better international understanding among the peoples of many countries.

Benjamin Franklin believed sincerely in the power of an informed public. In an age when most diplomatic conversations were conducted in secret, he startled the world by carrying his ideas to the people.

John Adams said of his mission to France—"there (is) scarcely a peasant or citizen, a valet de chambre, coachman or footman, a lady's chambermaid or a scullion in the kitchen who . . . (does) not consider him as a friend to human kind. . . . "

Some of the highlights in this section will be the presentation of awards for service to the public in many countries of the world:

The International Benjamin Franklin Society's Gold Medal for "Outstanding Service to Mankind" and the Bronze Medal to high school youth.

The United States Congress' Franklin Medal to the Scientific and Educational Societies of which Franklin was a member.

The City of Philadelphia Franklin Medal to the man and to the woman who have contributed most to better international understanding in the post-war decade.

The Poor Richard Medal of Achievement for distinguished service—and the Almanack Medal for outstanding cooperation in the Anniversary.

Section 3—Publishing, Broadcasting and Communications

Poor Richard's life-long fight for freedom of speech, religion and opportunity was based upon his abiding faith in the power of a free press.

Many Associations, representing more than 5000 newspapers, magazines, radio and television stations will cooperate in Franklin's own manner —publish or broadcast such news of the Celebration as will interest their readers or listeners. Poor Richard once said:

> If you would not be forgotten as soon as you are dead . . . either write things worth reading, or do things worth the writing.

Mailings of this Editorial Material will be made through the courtesy and cooperation of the Commonwealth of Pennsylvania, the City of Philadelphia, the National Franklin Committee and the American Mutual Alliance:

October, 1955, initial mailing of Program and background material on Franklin.

January, 1956, opening the Anniversary Year with events leading up to Franklin's Birthday, January 17.

March and May, 1956, News summaries of important papers delivered in many countries.

September, 1956, Summation of the Anniversary Year, with emphasis on ideas that contribute most to better international understanding.

Section 4—Science and Engineering

Benjamin Franklin's "Proposals" brought the teaching of practical and technical subjects into American colleges for the first time. Yet, despite the amazing progress of Technology since then, one of the most critical needs in the world today is for more and more young technicians, engineers and scientists.

Many great scientific and engineering societies, institutions and museums will combine in 1956 to provide facts that will help encourage more young men and women to prepare for such careers:

Literature distributed through the Museums of Science will be furnished by Joint Councils of Science and Engineering Societies, General Electric Company, National Association of Manufacturers, Leeds & Northrup, Sun Oil Company, The Advertising Council, and others.

The English-Speaking Union's King George VI Memorial Scholarships for technical students will be given high visibility, as will such scholarships by many industrial firms.

The John Scott Award for Distinguished Invention will be presented at the Engineers' Club, Philadelphia, on January 17, and the Franklin Medal for outstanding contributions to science will be presented at The Franklin Institute on January 18.

Section 5—Medicine and the Public Health

Few people think of Benjamin Franklin as one of the pioneer leaders in the Medical Profession. Yet it was he who helped found America's first public hospital and devised a plan for public and state cooperation in the care of all who suffered.

His vigorous championship of the layman's responsibility for aiding medical research helped to lay the foundations on which this great Profession has lengthened our lives and eased our pain.

Features in this section will include:

Evaluation of Franklin's prediction for a lengthened life span, by the College of Physicians, Philadelphia.

Important papers on the progress of medicine by the Medical Society of London and the Académie nationale de Médecine, Paris—both of which honored Benjamin Franklin by election to membership.

"Hospitals of the Future," by the Pennsylvania Hospital, and "Health Careers—Challenge and Opportunity," by the American Hospital Association.

Section 6—Printing, Advertising and the Graphic Arts

Many of the Societies, Associations and Institutions in this section will carry on Franklin's great fight for continued freedom in the communication of ideas, in publicity, advertising, publishing and broadcasting.

"When men differ in opinion" Poor Richard wrote in his *Apology for Printers*, "both sides ought equally to have the advantage of being heard by the public; and when truth and error have fair play, the former is always an over-match for the latter."

"International Printing Week" and "Printing Education Week" (January 15–21, 1956) will be, as always, dedicated to "Benjamin Franklin, Printer."

The Advertising Federation of America, in its National Convention in May, 1956, will re-affirm the ideals of advertising's first great copywriter and "Patron Saint."

Numerous advertisers will feature Frankliniana in broadcasts, advertisements and literature.

Section 7—Finance, Insurance, Private Enterprise

The year 1956 will be a time for re-assessing the principles of Free Enterprise as taught by Benjamin Franklin.

It was Franklin who pointed out that the privilege of the individual to become successful carried with it the obligation to help those who were less fortunate. He advocated old age pensions, help for the needy, all known types of insurance against loss by factors beyond control, crop insurance for farmers, public service as a duty for all.

Had these principles been more widely understood and practiced, the system of private enterprise would have swept more irresistibly across the face of the world.

Papers on Franklin's theories of Private Enterprise will be presented by The Philadelphia Contributionship, The Franklin Life Insurance Company, The New York Two-Fifty Committee, American Mutual Alliance, and others.

"National Thrift Week" representing about 5000 banking and financial institutions, will be dedicated, as always, to the "Father of Thrift."

The North America Companies, National Fire Protection Association and many local fire companies will join in emphasizing the most modern means of prevention of loss by fire and the forces of nature.

Section 8—Religion, Fraternal and the Humanities

The famous French Ambassador, Jules Jusserand, said:

> He (Franklin) taught us something we have never forgotten . . . that no man should have a better chance in this world because he happened to be born in some certain caste or class.

Cooperating groups in this section will stress Franklin's teaching that *moral science* must keep pace with *pure science* if the world is to progress towards peace and a higher civilization.

All religious faiths are invited to recall the man who placed Freedom of Worship as one of the great ideals of humanity.

The Presbyterian Church will celebrate also in 1956 the 250th Anniversary of the establishment of the first presbytery in the United States.

The Masonic Fraternity will pay tribute to the man who helped change their membership from a limited group to representatives of all classes.

Patriotic Societies will remember the pledge Franklin made at 16—"to do all within my power to help my countrymen."

Section 9—Agriculture, Horticulture and Botany

Benjamin Franklin believed that the foundation for world peace must start with agriculture. The fears of famine and malnutrition make a climate that breeds wars and revolutions.

Agricultural Science today knows how to end those fears and to produce the foods needed for rapidly increasing populations and industrial workers.

Sharing this knowledge, according to Ezra Taft Benson, U. S. Secretary of Agriculture, in a paper on Franklin, makes the Agricultural Scientist as important to building permanent peace as even the greatest Statesman.

The Royal Society of Edinburgh and the Philadelphia Society for Promoting Agriculture will discuss the ways and means of meeting the food demands of the future.

The John Bartram Association will cooperate in spreading the beautiful Franklinia Tree to other countries, in memory of Bartram's and Franklin's plan of exchanging useful and decorative plants as a help to world friendship.

Section 10—Music, Entertainment and Special Events

Henry Butler Allen, Director of The Franklin Institute, aptly called Franklin "the Philosopher with a twinkle in his eye."

Despite his thrift and industry, Franklin was a determined advocate of entertainment to lighten and pleasure the process of living. He improved Richard Puckeridge's *Glasspiel* (musical glasses) so greatly that the instrument he perfected (which he called the Armonica) enjoyed great popularity both in Europe and America. He also composed popular songs. He took the lead in recommending organized college sports and recreation.

It was at a picnic on the banks of the Schuylkill that he first demonstrated the use of electricity for cooking and entertainment. Many of his toughest battles were won by the sparkling wit that amused as well as influenced his listeners.

This side of Franklin's life will be highlighted in 1956 by many special events:

His music will be played by orchestras and over the air.

The Mozart Bicentennial Festival will include the music composed by Mozart and Beethoven for Franklin's Armonica.

The William L. Goldman Foundation has established a shrine to the technical development of the motion picture industry at the Nickelodeon at The Franklin Institute, whose past officers invented and first demonstrated the moving picture.

Gatherings at Franklin House in London will bring together the leading Societies in England which are cooperating in the Celebration.

Interesting Frankliniana and Exhibits of Franklin's life will be shown to the public by the Franklin National Bank, Gimbel Brothers, cooperating Museums, Libraries and Historical Societies.

The above are just a few of the highlights of the International Celebration. A much more complete listing is published in the Program.

Together, they all add up to the wide variety of exchange that delighted Poor Richard. For, along with the interest and entertainment, there runs the practical note of contributing to better understanding between peoples—his life-long objective.

"We may make these times better if we
bestir ourselves" said Poor Richard.

B. FRANKLIN AND THE SCIENTIFIC SOCIETIES *

BY

WILLIAM E. LINGELBACH [1]

American Philosophical Society

I

THE AGE OF ENLIGHTENMENT

Franklin and scientific societies were as mutually congenial as they were the natural expression of one of history's great revolutionary movements. The Enlightenment of the 18th Century embodied in itself the fruition of the discoveries and inventions of the western world since the Middle Ages, and with it the firm belief that the new knowledge and power should be used in a practical manner to improve the estate of man.

The chief aim of knowledge, said Bacon in his *Novum Organum* (1620), is the improvement of man's estate. The study of nature and its phenomena is therefore imperative in order that man discover by induction the knowledge to promote the welfare of humanity.

Bacon lived about the middle of the great revolutionary progress in human history between the Renaissance and the Enlightenment. He saw and felt only the first half of the impact of the geographical discoveries, the expansion of commerce and the steady progress in science, economics and politics of the modern age. The disciples of the Enlightenment, on the other hand, were alive to the miraculous achievements of the entire period and firmly believed that these were the bases for a new science and a new philosophy of life and action. Scholasticism had made way for humanism, Aristotelian philosophy and metaphysics like philosophy based on *a priori* assumptions and revelation were considered outmoded. Reason, experimentation, observation and deduction were regarded as the only means of arriving at truth and the knowledge of nature and man.

Copernicus and Brahe had led the way to observation, Galileo to experimentation. Kepler, Descartes and Newton had supplied the mathematical analysis and laws of physics. In his *Principia* Newton promulgated the law of gravitation, explained the movement of the planets and supplied a scientific interpretation of the universe. His achievements and fame still dominated the intellectual world as the 18th century progressed, and when

* The subject of this paper was originally to have been presented by the late President of the American Philosophical Society, the Hon. Justice Owen J. Roberts. Unfortunately his illness and unexpected passing deprive us of a great leader and his contribution to this Series. W. E. L.

[1] Former Secretary, Vice-President, and now Librarian, American Philosophical Society, Philadelphia, Pa., U.S.A.; Emeritus Professor of History, University of Pennsylvania.

the comet observed by his friend, Edmund Halley, in 1682, obediently returned in 1759 in accordance with Newton's formula, the possibilities of the new science seemed unlimited.

The geographical discoveries had dealt a staggering blow to man's conception of the earth and the narrow restricted ideas of civilization. William Harvey's discovery of the circulation of the blood (1628) developed the sense of man's relation to the rest of the animal world, suggesting not only comparative studies of different races of man and animals, but a new science of medicine.

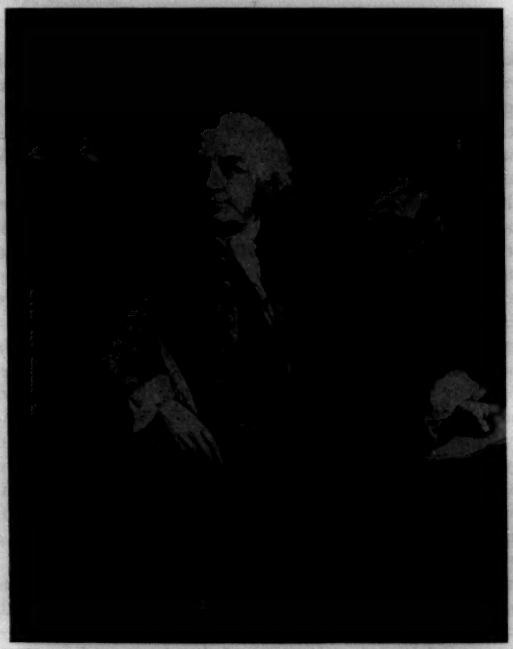


FIG. 1. Portrait, from life, of Benjamin Franklin by Mason Chamberlin.

In the field of botany Linnaeus developed a new and systematic classification of plants, which afforded an acceptable medium for communications on plants and plant life to the Bartrams, Peter Collinson, John Mitchell, Henry Ernst Muhlenberg and many others. In the field of chemistry Priestley, following in the footsteps of Boyle and Cavendish, gave the *coup de grace* to the phlogiston theory, discovered the new gas, to which Lavoisier gave

the name "oxygen," and developed the quantum theory—the new basis for the study of chemical reactions. The geological studies of James Hutton drew attention to the age of rocks and the story of geological strata. Meanwhile Buffon's great work in many volumes and editions (1)[2] popularized and stimulated the study of zoology and comparative anatomy, even though his suggestion of the common origin of the horse and the ass, man and the monkey, was very tentative because, as he said, contrary to the Bible. Jefferson's refutation of his (Buffon's) thesis that the Americas were not adapted to the highest physical development is well known.

Meanwhile, through all this period since the days of Gutenberg and Caxton, the printing press, that dynamic agency of progress so favored by Franklin, was disseminating and democratizing the new discoveries. Pamphlets and books multiplied; horizons widened; new heavens and a new earth appeared. Natural law was substituted for the supernatural. Reason was exalted above everything else, and man's capacity to discover the laws of nature and use them was taken for granted. Hence also the glorification of the individual and his inalienable rights. The potentialities of science seemed boundless.

All these sweeping tenets of the new philosophy, combined with the bewildering discoveries and publications by a brilliant group of scientists and philosophers, postulated a realistic approach to the problems of life. Experimentation, observation, accurate recordings and communication became accepted scientific procedure. This in turn led directly to the associations of men of similar interests and the establishment of scientific societies, academies, museums and laboratories. Publications in the form of transactions and memoirs followed naturally, and in this diffusion of knowledge the emphasis gradually shifted to the practical, that is, "useful knowledge." To the Enlightenment, Plutarch's apology for Archimedes, who put his mathematical formulas to practical use in frightening the Romans into abandoning the siege of Syracuse, was totally foreign.

II

SOCIETIES AND ACADEMIES

In general the initiative in the forming of scientific societies came from scholars and scientists anxious to confer with men of like interests. As time passed, royal or princely patronage was sought and formal incorporation effected. Indeed the story of the rise and growth of academies and scientific societies reveals better than anything else the extreme vitality and ferment among intellectuals of the 17th and the 18th century. Beginning with the Accademia dell'Cimento in 1560, the movement had spread rapidly through Italy into France and England and more slowly into the Germanies and Russia. The story of those that elected Franklin to membership appears in the successive papers of this volume. Altogether twenty-

[2] The boldface numbers in parentheses refer to the references appended to this paper.

four to which he was elected a member are listed in the Institute's leaflet, which states:

> To him, the great scientific and educational societies provided the ideal forum for this purpose. He was an active and corresponding member of twenty-four such societies—in England, France, Scotland, Germany, Holland, Italy, Spain, Russia and America.

While his relationship to some of these was quite slight, it was very close with others. He was an active member of the ranking societies of England, France and America. There were others not listed, which, according to the meaning of the word "science" in our day, would not appear in such a list, but which, on the basis of the broader use of the term in the 18th century, would be included. Moreover, those devoted to the social sciences proved to be Franklin's most effective forum for the dissemination of his political and even social ideas.

Franklin's entry into this new world was no accident. It was deliberate and by choice. Having reached what proved to be the exact middle point of his long life, he withdrew from printing and publishing and formed a partnership with David Hall, to whom he entrusted the management of the business in order to devote himself to science and other pursuits. Comparatively unknown abroad, he was soon recognized and step by step welcomed in the most exclusive scientific and social circles. Within a few decades no less a person than John Adams, who was not always too friendly towards Franklin's manner of doing things, could write: "His reputation was more universal than that of Leibnitz or Newton, Frederick or Voltaire, and his character more beloved and esteemed than any or all of them" (2).

This meteoric rise to fame and honors is usually, and in a sense quite correctly, ascribed to his *Experiments and Observations on Electricity*. On the other hand, it should not be overlooked that Franklin had served a long apprenticeship for the roles he was about to play. He had learned by experience the necessity of accurate observation and the value of good reporting and communications. He set up rules for discussion and study at an early age for his Junto (1727), and later, in his proposal for the first scientific society of the Colonies, the American Philosophical Society (1743), he introduced into its title a conspicuous feature of the Enlightenment, "A Proposal for Promoting Useful Knowledge. . . ." He had pioneered in many civic improvements: started the first subscription library of the Colonies (1731); invented the Franklin stove (1742); issued Proposals relating to the Education of the Youth in Pennsylvania (1749); founded the Pennsylvania Hospital (1751); initiated the Philadelphia Contributionship for Insurance of Houses against Loss by Fire (1752); and made his experiments and observations on electricity—to mention only the most important of his civic and humanitarian efforts to improve "the estate of man." He favored Deism against the theological teachings of the theologians. He accepted the concepts of natural rights, liberty, freedom of enterprise and

government by the people, formulated by Locke in his *Two Treatises of Government* (1690).

In every respect he was a logical candidate for membership in the scientific and other intellectual organizations of the period—a philosopher-scientist who by instinct and training not only subscribed to the new philosophies but advocated their practical application. This wide experience and training, added to his wisdom, wit and general ability, made him not only an outstanding philosopher—using that term in its broadest sense—but one whose appeal to all classes of men was without equal in his day. Writing on this aspect of Franklin's career, one of his most distinguished biographers said: "In the course of his long life Dr. Franklin was in touch with more varieties of human nature, perhaps, than any other man of equal eminence that ever lived" (3).

With these things in mind one would like to turn at once to Franklin and the Royal Society of London, easily the greatest of the societies in its influence on his scientific achievements and reputation. But we turn first to the society more intimately associated with Franklin than any other, one which owes its origin and early achievements to him—The American Philosophical Society.

The American Philosophical Society held in Philadelphia for Promoting Useful Knowledge

The first suggestions for the organization of the Society were apparently made to Peter Collinson by Franklin and John Bartram several years before Franklin issued *A Proposal for Promoting Useful Knowledge among the British Plantations in America* in 1743. By way of preface he draws attention to the fact that "the first Drudgery of Settling new Colonies . . . is now pretty well over; and there are many . . . in Circumstances that set them at Ease, and afford Leisure to cultivate the finer Arts, and improve the common Stock of Knowledge." Hence he proposes "that One Society be formed of Virtuosi or ingenious Men residing in the several Colonies, to be called *The American Philosophical Society,* who are to maintain a constant Correspondence"—at Philadelphia, that being the center of the Continent-Colonies; "that these Members meet once a Month, or oftner, at their own Expence, to communicate to each other their Observations, Experiments, &c." The subjects for discussion and correspondence are then enumerated in detail, emphasis being placed on the useful arts. Communications between the members and the Secretary are to pass "Postage-free," and such as "be thought of Publick Advantage," printed. In conclusion, Franklin, "the Writer of this Proposal, offers himself to serve the Society as their Secretary, 'till they shall be provided with one more capable."

The Society, obviously patterned after the Royal Society of London, was duly organized. The immediate results were, however, disappointing. Distances were great and communications very difficult, Bartram complained,

and the experience of the early years was discouraging. At any rate the story is quite obscure, the records being lost. In the 1760's, however, the Society came to life partly through rivalry with another Society which claimed descent from the Junto, and called itself The American Society, held at Philadelphia, for promoting and propagating useful Knowledge. In 1768 agreement was reached between the two organizations and they were united in one body as the American Philosophical Society, held at Philadelphia for Promoting Useful Knowledge. In the elections for the Presidency Franklin defeated the candidate of the Proprietary party, and the reorganized Society, with a total membership of 251, began its history under his leadership.

In 1780, in the midst of the War of Independence, the Society obtained its charter of incorporation from the Commonwealth of Pennsylvania. It reiterates the objectives of the Proposal, but stresses somewhat more the international ideals of the republic of scientists and scholars so characteristic of the Enlightenment:

> And whereas nations truly civilized (however unhappily at variance on other accounts) will never wage war with the Arts and Sciences, and the common Interests of humanity:
>
> . . . Be it further enacted by the authority aforesaid, That it shall and may be lawful for the said Society by their proper officers, at all times, whether in peace or war, to correspond with learned Societies, as well as individual learned men, of any nation or country, upon matters merely belonging to the business of the said Society, such as the mutual communication of their discoveries and proceedings in Philosophy and Science; the procuring books, apparatus, natural curiosities, and such other articles and intelligence as are usually exchanged between learned bodies, for furthering their common pursuits; Provided always, That such correspondence of the said Society be at all times open to the inspection of the Supreme Executive Council of this Commonwealth.

Franklin had taken his obligations seriously, and, although extremely busy at home and later absent first as Colonial Agent in England and then as Minister to France, he was re-elected President year after year till his death in 1790. The explanation of this lies not only in the pride and satisfaction of Franklin's compatriots in the honors he was receiving abroad, but in the fact that despite it all he kept in constant touch with the Society and its activities. He suggested and nominated distinguished scientists and scholars for election to membership. Among the names of members of the Society printed at the end of the first volume of the *Transactions* (1771) there are twenty-five Europeans—fourteen from England, two each from Scotland and Ireland, three from Sweden, one each from France (M. Buffon), Germany, Holland and Italy. Between 1771 and 1786 altogether fifty-five foreigners were elected, nineteen of them French, and from 1786 to 1793 sixty-nine, twenty-one French and twenty-seven British (Fig. 2). In all cases they were active members who reacted enthusiastically to this gesture of the New World on behalf of the universality of science. In a remarkable letter to the Society the great Lavoisier wrote (4):

Paris le 12 avril 1774.

Messieurs

Mon objet en entreprenant l'ouvrage que je vous prie d'accepter a eté de fixer l'attention des savants sur une Theorie nouvelle qui semble promettre de grandes decouvertes à la chimie; c'est en angleterre que cette Theorie a pris naissance le fond de cet ouvrage appartient donc a votre nation; heureux si contribuant à l'objet commun qui doit animer tous les Savants j'ai pu augmenter de quelque chose la masse des connoissances acquises, plus heureux encore d'avoir trouvé cette occasion d'entrer en correspondance avec une Société celebre qui a porté le flambeau de la verité jusques dans un nouveau monde et qui a contribué plus qu'aucune autre a etendre l'empire de la philosophie.

Je suis avec Respect

Messieurs

Votre tres humble et tres obeissant Serviteur

LAVOISIER

MM. de la Société philosophique de philadelphie.

FIG. 2. Certificate of membership issued by the Society to Frederick Eugene Francis, Baron de Bielen Bertholf, and signed by Franklin after his return from France.

Throughout Franklin, though absent abroad so much of the time, corresponded constantly with the Society. In addition to suggesting foreign scholars for election, he personally undertook the distribution of the Society's *Transactions* (Fig. 3). Indeed, it is to his enterprise on this score that the Society's library owes its fine collections of foreign academies' serial publications. Even after his return from France this continued a matter of

interest and concern to him, witness the following letter to his young friend and successor in Paris, Thomas Jefferson (5):

Philada. Oct. 8, 1786.

Dear Sir

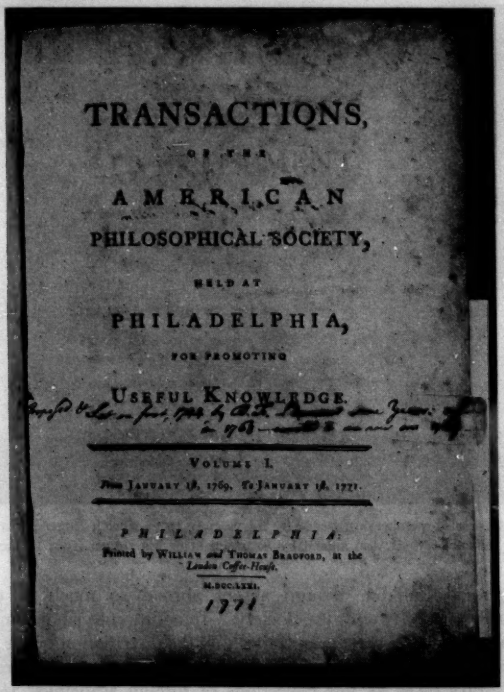
I obey with Pleasure the Order of the Philosophical Society, in transmitting to you the enclos'd Proof of their Respect for you, and of the honour they have done themselves, in chusing you one of their Members.

With this you will receive several Diplomas for foreign Gentlemen in different Parts of Europe, which I imagine you may convey to them thro' the Ministers of different Courts residing at Paris; and hope you will excuse my giving you the Trouble. There are some also for Gentlemen in France.

I have the honour to be with the highest Esteem, Sir, Your Excellency's most obedt. humble Servant,

B. FRANKLIN

I send herewith the 2d Vol. of our Transactions, which please to accept.


TRANSACTIONS,

OF THE

AMERICAN

PHILOSOPHICAL SOCIETY,

HELD AT

PHILADELPHIA,

FOR PROMOTING

USEFUL KNOWLEDGE.

VOLUME I.

From JANUARY 1st, 1769, To JANUARY 1st, 1771.

PHILADELPHIA:

Printed by WILLIAM and THOMAS BRADFORD, at the London Coffee-House.

M.DCC.LXXI.

1771

FIG. 3. First volume of the Society's *Transactions* (1771). Widely distributed by Franklin, it brought the youthful American society forcibly to the attention of the scientific and learned societies of the Old World.

The Society was well established and active when Franklin finally returned home in July of 1785, even though it was financially somewhat embarrassed by the expenses incurred in the erection of Philosophical Hall. The Pennsylvania Assembly had given the Society a lot on Independence Square on which to erect a building for its purposes. Since the cost of the building was entirely defrayed by the private subscriptions of members, it proved a major concern of the Society for a number of years. Franklin's initial contribution of £100, repeated after his return and later followed by a loan of £600, helped to complete the structure—"put the roof on."

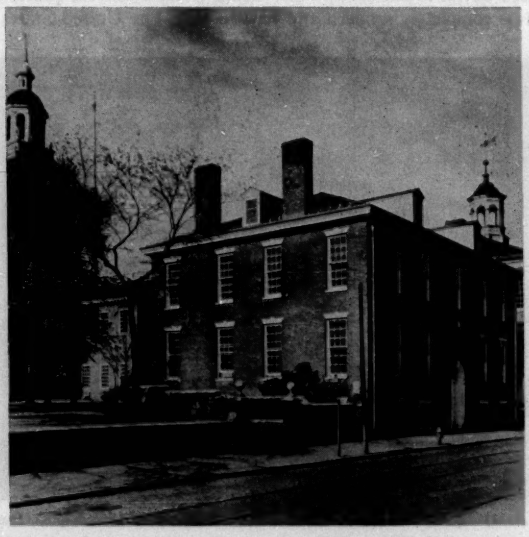


FIG. 4. Philosophical Hall, home of the American Philosophical Society since 1789, with the tower of Independence Hall in the left background.

Happily he saw its completion, though his failing health made attendance at the Hall very difficult and at such times the Society met by previous arrangement at his home in Franklin Court.

The possession of Philosophical Hall (Fig. 4) as a home in historic Philadelphia has proved a constant stimulus to the maintenance of the Franklin tradition in the Society and the city at large. It has afforded a place for its regular meetings, offices for the staff, rooms for the library and cabinets, and the assembling and publishing of his writings. During the last two decades in particular an active program of collecting, studying and publishing has been in progress. Two years ago, in anticipation of this

250th Anniversary of Franklin's birth, the Society agreed to cooperate with Yale University under their joint auspices in the publication of a new and major edition of The Papers of Benjamin Franklin, in what is expected to be a superb edition of twenty-five or more volumes.

Furthermore, in response to the increasing demands on its Library, the Society has signed an Agreement with the National Government for the restoration in part by the Society of the building of the Library Company of Philadelphia, inaugurated by Franklin and his friends in 1731. This fine old Georgian building (Fig. 5), designed by William Thornton, will be reproduced on the Fifth Street side, facing Independence Square, while the rest will be completely modern and functional. The United States Govern-

FIG. 5. Library Hall (1790–1887) of the Library Company of Philadelphia, founded 1731.

ment, as an expression of its deep interest in the maintenance of the intellectual and cultural activities in this historic area of the city, has made available to the Society the former site, with generous provision for expansion in the future.

The American Academy of Arts and Sciences

The second learned society in America in point of time and prestige, of which Franklin was a member, was the Academy of Arts and Sciences of his native city, Boston. It was founded upon the suggestion John Adams made on the occasion of a dinner at Harvard College in 1779 in honor of the French ambassador, Le Chevalier de la Luzerne. Referring to his experi-

ences among the academicians and other men of science and letters abroad and "the compliments he had heard in France upon the Philosophical Society at Philadelphia" (6), he readily convinced his colleagues of the need of an academy for Boston. Its organization was promptly effected and in 1780 the General Court of Massachusetts granted the charter of incorporation. Like the charter of the Philosophical Society, that of the Academy also stresses applied science, that is, science pursued not for its own sake or even for the sake of truth, but for the service of the citizenry and the material benefit of man. Its first President, James Bowdoin, was a correspondent and close friend of Franklin's and in 1781 Franklin was elected a member (Fig. 6). Publication of the Academy's proceedings was taken for granted

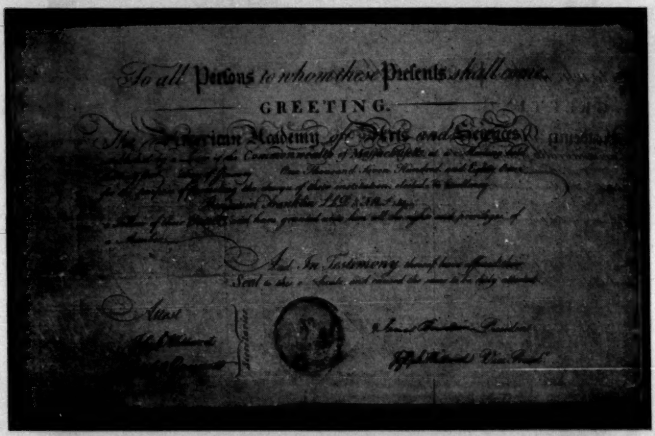
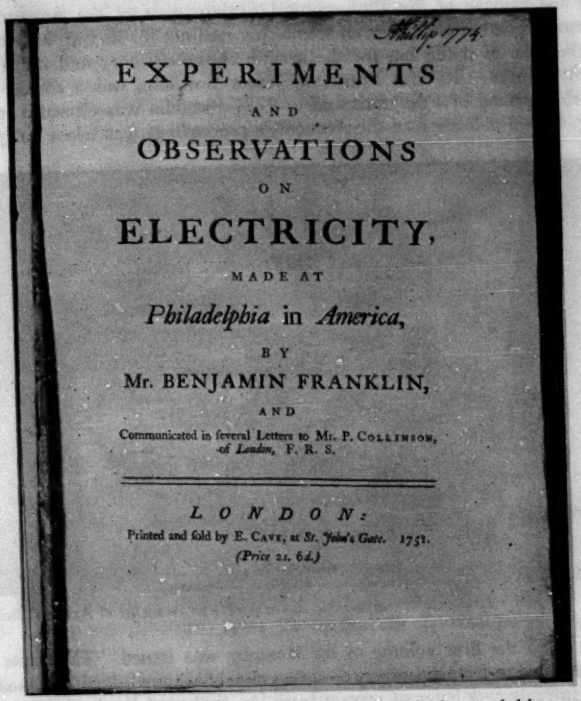


FIG. 6. Franklin's certificate of membership in the American Academy of Arts and Sciences.

and in 1785 the first volume of its *Memoirs* was issued. The name was obviously due to French influence—a fact clearly acknowledged by Manasseh Cutler in reply to a letter of protest from Dr. Stokes of England (7):

> . . . You object to the title as savoring too much of the air of France, and as improper when applied to a Society. You will recollect that the American Academy was instituted at a time (1780), when Britain was viewed in this country as an inveterate enemy, and France as a generous patron. Although philosophers ought to divest themselves of all those prejudices which national contentions and combinations naturally excite, yet I doubt not it was the intention of those concerned in establishing the institution to give it the air of France, rather than that of England, and wished to be considered as following the Royal Academy, rather than the Royal Society. But, however this might be, it was of importance that the title should clearly and concisely distinguish this from a similar institution at Philadelphia, whose title was professedly copied from the Royal Society.

The exchange of the Academy's *Memoirs* for the Society's *Transactions* was duly arranged between Franklin and Adams, and in his last Will Franklin bequeathed his folio edition of *Les Arts et les Métiers* to the Academy, having previously willed his *History of the Academy of Sciences, Paris,* to the Philosophical Society.


Phillips 1774.

EXPERIMENTS

AND

OBSERVATIONS

ON

ELECTRICITY,

MADE AT

Philadelphia in *America,*

BY

Mr. BENJAMIN FRANKLIN,

AND

Communicated in several Letters to Mr. P. COLLINSON, of *London,* F. R. S.

LONDON:

Printed and sold by E. CAVE, at *St. John's Gate.* 1751.

(Price 2s. 6d.)

FIG. 7. Franklin's *Experiments and Observations on Electricity* is regarded by many as the pioneering publication of the Age of Electricity.

The Royal Society of London

The prestige of the Royal Society of London throughout the British Empire and the world was *sui generis.* It reflected not only the sovereign patronage of the King and Parliament but, what was even more important, the spirit of the great Newton, which still pervaded its deliberations. Only a few representatives from the Colonies were elected—nine from Massachusetts, three from Pennsylvania, three from Virginia, and one each from

Connecticut, Rhode Island and the Carolinas. Membership was a coveted distinction and was awarded with discrimination. Franklin's case was no exception. His name appears in the minutes during the '40's. His communications on electricity were read before the Society in 1751 and published (Fig. 7) under the sponsorship of Peter Collinson, a distinguished member. A translation of the *Experiments and Observations on Electricity* into French by Dalibard and *Observations concerning the Increase of Mankind,* had appeared before the Royal Society, in 1753, awarded Franklin the coveted Copley Medal (Fig. 8) for his electrical experiments. Membership, however, did not come till April 29, 1756 (Fig. 9).

From that time on, however, until the controversy with the Colonies moved into its crisis, Franklin was an active member, serving not only on different committees but on the Council. His advice was naturally sought

FIG. 8. The Copley gold medal is awarded annually to the living author of such philosophical research, either published or communicated to the Royal Society, as may be considered by the Council as deserving of that honor.

on matters relating to electricity, navigation and exploration. He was in constant touch with the Society's major projects in these fields, such as Commander Cook's expedition to the South Seas, the Mason-Dixon survey, plans for the transit of Venus in 1769, experiments for measuring the attraction of hills and mountains, not to mention the controversy with Wilson and others over the merits of pointed versus round lightning rods, in which the King himself finally intervened in favor of ball points, only to be rebuked by the Society. Franklin had many intimate friends among the members. One of his closest, Sir John Pringle, who travelled with him on the Continent, was elected President in 1782. In 1784, the year after the signing of the Treaty of Versailles, another President, Josiah Banks, presented him

with one of its five additional gold medals, struck in honor of Captain Cook, a remarkable testimony to the universality of science and Franklin's favored doctrine of conciliation.

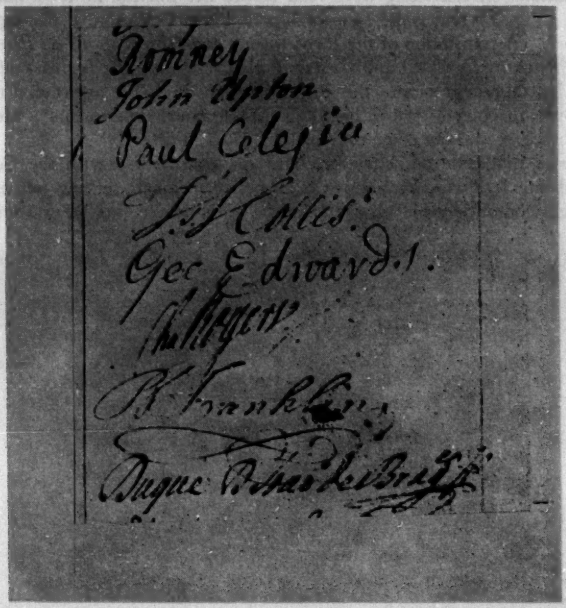


FIG. 9. Franklin's signature with those of others in the Royal Society's Roll Book (8).

The Royal Society of Arts

The Society for the Encouragement of Arts, Manufactures and Commerce, later known as the Royal Society of Arts, was also popularly known as the Premium Society. Franklin was invited to become a corresponding member by William Shipley, the Secretary, brother of Franklin's close friend, Jonathan Shipley, Bishop of St. Asaph's. In a letter of September 13, 1755, found among our Franklin papers, he tells of having received Franklin's "Proposal for Promoting Useful Knowledge among the British Plantations in America" through Dr. Alexander Garden of South Carolina, and, having communicated it to the members at their Board Meeting, he was writing to ask Franklin to become a corresponding member (9). Franklin's characteristic reply is dated Philadelphia, November 27, 1755 (10). In it he accepts the invitation, offering 20 guineas

> to be apply'd in Premiums for some Improvement *in Britain*, as a grateful, tho' small Return for your most kind and generous Intentions of Encouraging Improvements *in America*. I flatter myself, from that Part of your Plan, that those Jealousies of her Colonies, which were formerly entertained by the Mother Country, begin to subside. I once wrote a little Paper, tending to show that such Jealousies with regard to Manufactures were ill-founded. It was lately printed at Boston at the end of a Pamphlet which I take the Liberty to send you. Never be discouraged by any Apprehension that Arts are come to such Perfection in England as to be incapable of farther Improvement. As yet, the Quantity of Human Knowledge bears no Proportion to the Quantity of Human Ignorance. . . .

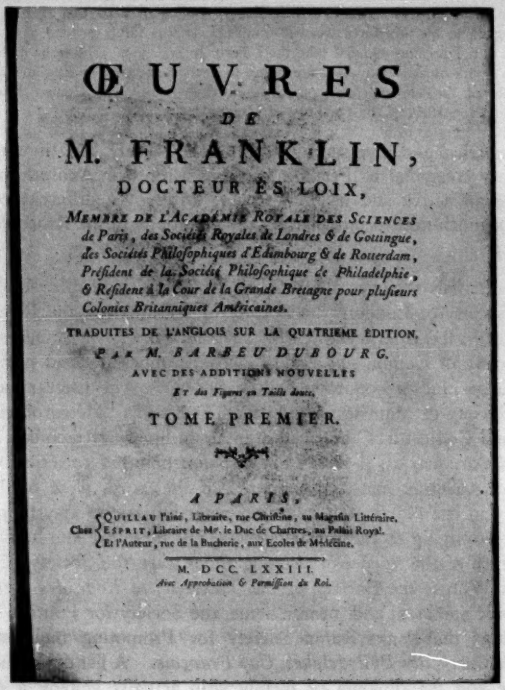
The practical and diverse objectives of the Society, like the membership, proved very congenial to Franklin, and, as Professor Andrade points out, he became an active and useful member, serving on different committees and giving much-needed information on conditions in the American Plantations (11).

Other British societies that elected Franklin to membership were the Medical Society of London, the Society of Antiquaries, the Royal Society of Edinburgh, the Literary and Philosophical Society of Manchester. The Royal Society of Edinburgh, among whose members he had many staunch friends, made him an honorary Fellow (1783). The Literary and Philosophical Society of Manchester published Franklin's "Meteorological Imaginations and Conjectures" and lists him as an honorary member. Like the Society of Antiquaries, it raises the question of other societies, which, although not scientific in the usual sense of the word, were of the utmost importance in Franklin's political and civic activities. Today they might be classed as belonging to the social sciences, but these are late arrivals in the nomenclature of the sciences. Among them were the Society of the Constitutional Whigs; the Society of the Thirteen; *la Loge des Neuf Soeurs* and Masonic affiliates; and, nearer home, the Society for Political Inquiries, Philadelphia; the Pennsylvania Society for Promoting the Abolition of Slavery; *le Cercle des Philadelphes, Cap François*. A list of the members of the *Cercle* and the diploma of membership actually employ a decorative piece found in our collection of Franklin stencils.

L'Académie Royale des Sciences (Paris)

Considering the great popularity of Franklin among the French later, it is surprising that he was not elected to the Academy before 1772. True, Barbeu Dubourg's *Oeuvres de M. Franklin* (Fig. 10) did not appear till 1773, and even Poor Richard had not been popularized as *La Science du Bonhomme Richard*, with its five issues in one year. Besides, the Academy was very exclusive. There were only eight foreign members, and l'Abbé Nollet, one of its leaders, was very critical of Franklin's electrical theories. By 1772, however, the Academy greeted his election as a foreign member

(*Associé étranger*) with much enthusiasm. In a letter among our Library's Franklin Papers, Jean-Baptiste Le Roy, inviting Franklin to its meeting, reminded him that commissioners from the Academy would call on him to



ŒUVRES
DE
M. FRANKLIN,
DOCTEUR ÈS LOIX,
MEMBRE DE L'ACADÉMIE ROYALE DES SCIENCES de Paris, des Sociétés Royales de Londres & de Gottingue, des Sociétés Philosophiques d'Edimbourg & de Rotterdam, Président de la Société Philosophique de Philadelphie, & Résident à la Cour de la Grande Bretagne pour plusieurs Colonies Britanniques Américaines.
TRADUITES DE L'ANGLOIS SUR LA QUATRIEME ÉDITION,
PAR M. BARBEU DUBOURG.
AVEC DES ADDITIONS NOUVELLES
ET des Figures en Taille douce.
TOME PREMIER.
A PARIS,
Chez { QUILLAU Pairé, Libraire, rue Christine, au Magasin Littéraire, ESPRIT, Libraire de Mgr. le Duc de Chartres, au Palais Royal. Et l'Auteur, rue de la Bucherie, aux Ecoles de Médecine.
M. DCC. LXXIII.
Avec Approbation & Permission du Roi.

FIG. 10.

examine the apparatus invented by him (12). On his part Franklin in a letter to William Franklin, August 22, 1772, wrote (13):

> . . . last night I received a letter from Paris, of which the enclosed is an extract, acquainting me that I am chosen *Associé Etranger* (foreign member) of the Royal Academy there. There are but eight of these *Associés Etrangers* in all Europe, and those of the most distinguished names for science. The vacancy I have the honour of filling was made by the death of the late celebrated Van Swieten of Vienna. This mark of respect from the first academy in the world, which Abbé Nollet, one of its members, took so much pains to prejudice against my doctrines, I consider as a kind of victory without ink-shed, since I never answered him. I am told he has but one of his sect now remaining in the Academy. All the rest, who have in any degree acquainted themselves with electricity, are, as he calls them, *Franklinists*. [Fig. 11.]

In his letter to the Duke de Vrillière, who had informed him of his election Franklin wrote (14):

> Dear Sir,
>
> It was with the greatest pleasure I received the information your Grace has condescended to give me, of my nomination by the King to fill a vacancy in the Academy of Sciences, as *Associé Etranger*. I have a high sense of the great honour thereby conferred on me, and beg that my grateful acknowledgments may be presented to his Majesty. With the greatest respect, &c.—*London, September 4th, 1772.*

ajoutées.
La place d'Associé-Étranger qu'il occupoit dans cette Académie, a été remplie par M. Franklin, de la Société royale de Londres.

FIG. 11. The concluding sentence in the *Histoire de l'Académie Royale des Sciences*, 1772, referring to Franklin's election to that distinguished body (15).

His relations with the Academy were never as close as were those he had with the Royal Society, but many of its most distinguished members became his intimate friends. His communications on the aurora borealis were read before the Academy in 1779 and later published. During the same year he assisted Marat in his efforts to bring his ideas on fire before the Academy. He was on intimate terms with Lavoisier, visiting his laboratories to observe his experiments with oxygen.

L'Académie Royale de Médecine, Paris

Franklin's election to this rather select body is attested by a certificate of membership and a letter of June 1777 (16). We have a record of his communications in a letter to Vicq d'Azyr of July 20, 1777, in regard to the length of time infection might remain in dead bodies. In 1791 the Academy joined many others throughout France in special commemorative ceremonies.

L'Académie Nationale des Sciences, des Belles-Lettres et des Arts de Lyon

On July 5, 1783, Franklin was made an associate member, and two years later was elected to full membership of the Academy (17).

La Société Royale de Physique, d'Histoire Naturelle et des Arts d'Orléans

This Society elected Franklin in 1785, the year of his return to Philadelphia, and in the notification of election expressed its desire to enter into correspondence with the American Philosophical Society (18).

La Reale Accademia di Scienze, Lettere ed Arti di Padova

In Italy some of the intellectual atmosphere of the Renaissance seems still to have survived despite political disunity and foreign domination. Certainly Franklin's scientific ideas quickly received enthusiastic, if critical, appreciation. Scientists like Volta, Beccaria and Fabbroni were among Franklin's early scientific associates. He was elected successively to the

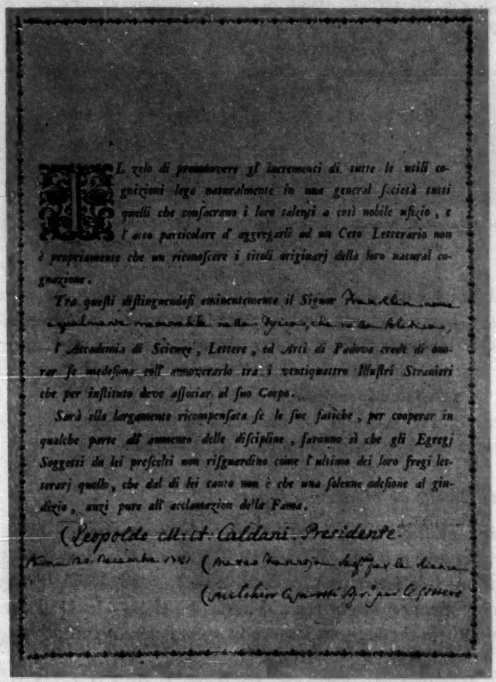


FIG. 12. Certificate of membership in La Reale Accademia di Scienze, Lettere ed Arti of Padua.

Academies of Padua (1781) (Fig. 12), Turin (1785) and Milan (1786). In his letter of acceptance to Padua Franklin promises to send natural history specimens after his return to America. A letter inviting Franklin to be a member of the Academy of Turin is found in the Franklin Papers at the University of Pennsylvania, while that of Milan is in the Franklin Papers of our Society. The latter also has the first five volumes of the Turin

Academy's *Mélanges de Philosophie et de Mathématique*, bought at Dufief's sale of Franklin's Library. A decade ago the Society also acquired the papers of Beccaria, and it is at present considering the publication of a study by Professor Antonio Pace on Franklin in Italy.

La Real Academia de la Historia, Madrid

Franklin's election to the Academy in 1784 is closely associated with his friend, Conte de Campomanes, who was elected to the American Philosophical Society in the same year. It suggests the interest of historical societies in Franklin. The Society's *Transactions* were sent to the Academy (19).

Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, Rotterdam

The Dutch were among the first of the Continentals to recognize Franklin, the Society at Rotterdam electing him to corresponding membership in 1771, but the certificate and the report of the Society's action are the only evidence at the writer's command of Franklin's direct relations with the group.

Königliche Gesellschaft der Wissenschaften, Göttingen

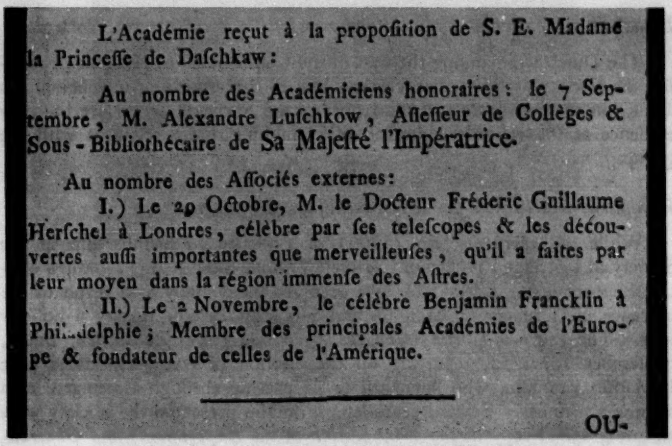
While the early election (1766) of Franklin to membership in the Society at Göttingen reflects a relatively prompt interest in Franklin's electrical experiments, it seems to have occurred incidentally as a result of the presence in Germany of Franklin and Sir John Pringle during a holiday tour. The journal, *Göttingische Anzeigen von gelehrten Sachen*, Bd. 1, September 13, 1753, reporting on the election of members, added that Benjamin Franklin, who happened to be passing through Göttingen, also became a member. Several years later Franklin presented the Society with an autographed copy of the 1769 edition of his *Experiments and Observations on Electricity*. There is, however, no evidence of any close contact. After all, since George III, Franklin's own sovereign, was also the ruler of Hanover, the Royal Society of London afforded the reasonable outlet for Franklin's scientific activity. Why the Royal Academy at Berlin failed to elect him was probably accounted for by the fact that Frederick the Great, like Catherine of Russia and Joseph II of the Empire, all considered themselves enlightened sovereigns and saw the implications of Franklin's political philosophy, the Emperor remarking that it was his business to reign and he would not endanger it by playing with Franklin's lightning.

The Imperial Academy of Sciences of St. Petersburg

The attitude towards Franklin in Imperial Russia reflects not only the reaction of the enlightened despots but a striking parallel with that of the

Soviets towards western science in the 20th century. As in recent years, official bureaucracy dominated Russian scientific thought and action. The Empress Catherine II looked askance at Franklin as a rebel. In the summer of 1752 the St. Petersburg *Monitor* carried reports of Franklin's experiments, even descriptions of the lightning rod. The Russian scientists Lomonovox and Rikhman were apparently also working on atmospheric electricity, but after Rikhman's accident and death the former was bitterly attacked by the conservative academicians, while the Empress, according to Khrapovisky's Diary, declared she did not like Franklin. His bust did not appear in the Hermitage. Poor Richard was a dangerous, adroit republican!

But the Princess Ekaterina Romanova Dashkova had met Franklin in



L'Académie reçut à la propoſition de S. E. Madame la Princeſſe de Daſchkaw:

Au nombre des Académiciens honoraires: le 7 Septembre, M. Alexandre Luſchkow, Aſſeſſeur de Collèges & Sous-Bibliothécaire de Sa Majeſté l'Impératrice.

Au nombre des Aſſociés externes:

I.) Le 29 Octobre, M. le Docteur Fréderic Guillaume Herſchel à Londres, célèbre par ſes teleſcopes & les découvertes auſſi importantes que merveilleuſes, qu'il a faites par leur moyen dans la région immenſe des Aſtres.

II.) Le 2 Novembre, le célèbre Benjamin Francklin à Philadelphie; Membre des principales Académies de l'Europe & fondateur de celles de l'Amérique.

OU-

FIG. 13. Extract from Minutes of the Imperial Academy of Sciences, St. Petersburg, 1789.

Paris in 1780 and become his warm friend and admirer. At a meeting of the Academy on November 2, 1789, she expressed her astonishment that the famous Franklin was not among the foreign members of the Academy. She had the Secretary propose his name, and "this revered and celebrated scholar received all the votes and was unanimously elected" (20) (Fig. 13).

Two days later the Princess, as President of the Academy, sent the following letter in English to Franklin in Philadelphia (21):

St. Petersburg, 4 November, 1789.

Dear Sir,

Having always supposed, and even cherished the idea, that you were a member of the Imperial Academy of Sciences, which is at St. Petersburgh under my direction, I was greatly surprised, when, reviewing the list of its members some days ago,

I did not find your name in the number. I hastened therefore to acquire this honor for the Academy, and you were received among its members with an unanimous applause and joy. I beg you, Sir, to accept of this title, and to believe that I look upon it as an honor acquired by our Academy.

. . . . . .

PRINCESS OF DASCHKOFF.

FIG. 14. This painting by Benjamin West, a Philadelphian compatriot of Franklin and President of the Royal Academy for many years, is one of the best known allegorical representations of Franklin's experiments on electricity.

The amazing progress in science so largely fostered in Franklin's day by scientific societies and today accelerated by scores of other agencies—Federal, State and municipal governments, industrial foundations, universities and academies—suggests Franklin's prophetic letter of February 8, 1780, from Passy to his friend Dr. Priestley (22):

Dear Sir,

Your kind Letter of September 27 came to hand but very lately, the Bearer having staied long in Holland. I always rejoice to hear of your being still employ'd in experimental Researches into Nature, and of the Success you meet with. The

rapid Progress *true* Science now makes, occasions my regretting sometimes that I was born so soon. It is impossible to imagine the Height to which may be carried, in a thousand years, the Power of Man over Matter. We may perhaps learn to deprive large Masses of their Gravity, and give them absolute Levity, for the sake of easy Transport. Agriculture may diminish its Labour and double its Produce; all Diseases may by sure means be prevented or cured, not excepting even that of Old Age, and our Lives lengthened at pleasure even beyond the antediluvian Standard. O that moral Science were in as fair a way of Improvement, that Men would cease to be Wolves to one another, and that human Beings would at length learn what they now improperly call Humanity!

I am glad my little Paper on the *Aurora Borealis* pleased. If it should occasion further Enquiry, and so produce a better Hypothesis, it will not be wholly useless. I am ever, with the greatest and most sincere Esteem, dear Sir, yours very affectionately

B. FRANKLIN.

Several of the amazingly prophetic ideas of this letter are obviously as pertinent today as when they were written. If the terrible threat of total destruction to civilization from the atom and nuclear fission leads at last to the elimination of war, Benjamin West's allegorical interpretation (Fig. 14) of Turgot's famous epitaph to the living Franklin

Eripuit caelo fulmen, sceptrumque tyrannis.

will be more appropriate than ever, though, Franklin himself would doubtless repeat his modest answer to Felix Nogaret (23):

J'ai reçu la lettre dans laquelle après m'avoir accablé d'un torrent de Compliments qui me causent un Sentiment pénible, car je ne puis espérer les meriter jamais. . . . Je vous ferai seulement remarquer deux inexactitudes dans le vers original. Malgré mes expériences sur l'électricité, la foudre tombe toujours a notre nez et a notre barbe, et quant au tyrans nous avons été plus d'un million d'hommes occupé a lui arracher son sceptre.

REFERENCES

(1) G. L. L. BUFFON, comte de, "Histoire naturelle, générale et particulière," 36 vols., Paris, 1749–1782.
(2) CHARLES FRANCIS ADAMS, editor, "The Works of John Adams . . . ," Boston, Little, Brown, 1850–56, Vol. 1, p. 660 (quoted from the *Boston Patriot*, 15 May, 1811).
(3) JOHN BIGELOW, "Franklin as the Man," *The Independent; a Weekly Magazine*, January 11, 1906, p. 69.
(4) American Philosophical Society Archives.
(5) J. P. BOYD, editor, "The Papers of Thomas Jefferson," Princeton, N. J., Princeton University Press, Vol. 10, 1954, p. 437.
(6) CHARLES FRANCIS ADAMS, editor, "The Works of John Adams," Vol. 4, p. 260. The interesting statement of this occasion is quoted from an account given by Mr. Adams in 1809.
(7) W. P. CUTLER AND J. P. CUTLER, "Life, Journals and Correspondence of Rev. Manasseh Cutler, LL.D.," Cincinnati, Clarke, 1888, Vol. 2, p. 267.
(8) Royal Society of London, "The Signatures in the First Journal-book and the Charter-book of the Royal Society, being a Facsimile of the Signatures of the Founders, Patrons and Fellows of the Society from the Year 1660 down to the Present Time," London, 1912, p. 27.

(9) American Philosophical Society, Franklin Papers, Vol. 1 (1), 38.
(10) Quoted by F. R. LEWIS, "Benjamin Franklin and the Society of Arts," *Pennsylvania History*, Vol. 6, 1939, pp. 16–17.
(11) E. A. DA C. ANDRADE, see this JOURNAL, p. 153. *Cf.* also D. HUDSON AND K. W. LUCKHURST, "The Royal Society of Arts, 1754–1954," London, John Murray, 1954, p. 63, 69, esp. 153.
(12) American Philosophical Society, "Franklin Papers," Vol. 71, 38[a], 44[b].
(13) ALBERT HENRY SMYTH, editor, "The Writings of Benjamin Franklin," New York, Macmillan, 1907, Vol. 5, p. 415.
(14) *Ibid.*, p. 415 n./.
(15) "Histoire de l'Académie Royale des Sciences," 1772, 1[e] Partie, p. 128 (Paris, 1775).
(16) American Philosophical Society, Franklin Papers, Vol. 46 (1), 54.
(17) *Ibid.*, Vol. 28, 10; Vol. 33, 154.
(18) *Ibid.*, Vol. 33 (2), 162½.
(19) *Ibid.*, Vol. 35, 63. Joseph Miguel de Flores to B. Franklin, May 18, 1787.
(20) Minutes of the meeting of the Conference of the Imperial Academy of Sciences, St. Petersburg, Vol. 4 (1786–1803), p. 204.
(21) JARED SPARKS, editor, "The Works of Benjamin Franklin," Boston, Hilliard, 1840, Vol. 10, pp. 405–406.
(22) ALBERT HENRY SMYTH, editor, "The Writings of Benjamin Franklin," New York, Macmillan, 1907, Vol. 8, pp. 9–10.
(23) *Ibid.*, Vol. 1, pp. 47–48.

"There is no Science, the Study of which is more useful and commendable than the Knowledge of the true Interest of one's Country; and perhaps there is no kind of Learning more abstruse and intricate, more difficult to acquire in any Degree of Perfection than This, and therefore none more generally neglected. Hence it is, that we every Day find Men in Conversation contending warmly on some Point in Politicks, which altho' it may nearly concern them both, neither of them understand any more than they do each other."

A Modest Enquiry into the Nature and Necessity of a Paper Currency
1729

CHANGING CONCEPTS IN SCIENCE

BY

LORD ADRIAN,[1] O.M.

The Royal Society

At the age of 76 Benjamin Franklin wrote from Paris to Joseph Priestley saying "I should rejoice much if I could once more recover the leisure to search with you into the works of nature, I mean the inanimate and not the animate or moral part of them: the more I discovered of the former the more I admired them, the more I know of the latter the more I am disgusted with them."

It was then too late for anything but pensive recollection: the choice had been forced on him a long time before. Franklin's gifts were too manifest to have allowed him much time for inanimate nature, for his abundant reasonableness and good will had marked him out for the service of his fellows in their immediate needs. If his character had been less estimable, if he had been more timid and less active in the service of his country, then no doubt our knowledge of the natural world might have advanced much faster. Certainly his lively curiosity and his experimental skill gave him the ideal equipment for a natural philosopher of the eighteenth century. If his talents had been less in demand who knows what discoveries he might not have made?

Coming nearly two hundred years later we have inherited the vast edifice of knowledge and practical achievement which took shape in the nineteenth century. We may not be as confident about its solidity as we should have been 50 years ago. Technical achievements are taken for granted and used without much enthusiasm and we have been forced to recognise that our understanding of the material world will never provide exact information about the particles which compose it. But although the foundations seem to need periodic renewal, the structure is still a fine monument to the human intelligence. It has brought Chemistry and Physics together with a common outlook and common techniques. Biology is within the framework and if the human mind still hovers uncertainly outside it can only stay there by proclaiming its divorce from the material activity of the human brain.

In the eighteenth century the structure was impressive enough, but it housed only one section of the natural world. Newton's laws governed the movement of all bodies celestial and terrestrial and the supremacy of

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the Newtonian System was so great that it appeared to point the way to all further discovery. Yet it did not follow that gravitation was the only force in action; in fact each new extension of natural knowledge seemed to demand a fresh complication. Elective attraction of different kinds of matter had to be added to explain chemical combination. An imponderable caloric fluid or self-repelling particles of caloric seemed to be needed to explain temperature effects. The orthodox chemist found no difficulty in supposing that the world was pervaded by a substance of negative weight, the phlogiston whose loss made bodies heavier. Electrical phenomena demanded one or two kinds of subtle fluid and magnetism another.

These were no doubt recognised as provisional hypotheses all aiming at a universe which could be formulated in mathematical terms, but the whole field of Biology was still beyond their reach. A few biologists accepted the full implications of a mechanical universe: most of them were still too busy with the preliminary stage of sorting out their data. Without biologically adequate systems for classifying plants and animals they could scarcely hope to understand their origins, and when they looked at their constituent structure the microscopes of those days left so much to the imagination that the animalculists and the ovists could see miniature human beings encased in the spermatozoon or in the ovum. In the face of such uncertainties it was better to base their arguments on the nature of the Deity or the history of creation. It is difficult for scientists of the present day to judge the Science of the eighteenth century unless they can remember its past and forget what came after it.

What came after in the nineteenth century was the triumphant verification of the eighteenth century dream of a world of particles in motion expressible in numbers and equations. Chemical combinations were found to obey numerical laws and to depend on the fixed properties of a limited variety of atoms. Chemical and electrical forces were equated by Davy and Faraday. Heat was reduced to motion. Magnetism and electricity were shown to be interdependent. The mass and then the energy in the universe could be taken as constant and it was proved that gases really behaved in accordance with the kinetic theory and that light had all the properties of a train of electro-magnetic waves.

As with Newton's system, the final stages in bringing together all these manifestations of matter or energy depended on the rigorous mathematical expression of a theory and the close agreement of the observed and calculated relations. And there has been the added satisfaction of finding the theories confirmed by each new extension of the range of observation. It is enough to point to our present knowledge of electro-magnetic waves and to all the evidence we now possess on the structure and behaviour of molecules.

The spectacular discoveries which led to this unified conception of the physical world led also to the technical advances which have affected every circumstance of our lives in it. They came in such abundance in the earlier

part of the nineteenth century that any philosophic difficulties could be set aside, or left to the few who could follow the arguments of Kant or Hegel. If the universe of whirling atoms was not the ultimate reality, it was the next best thing: there was still a great deal to be learnt about it and no one doubted the material benefits which would follow. It was, moreover, a universe of order and rule and so, like the Newtonian universe, it did not come into open competition with theological doctrine.

In the eighteenth century it had become possible to express doubts about the doctrine of the Trinity and even about the existence of a benevolent Creator. The spectacular disaster of the earthquake at Lisbon gave a text for unbelievers. But the Newtonian System supplied arguments both for the French materialists and for the clergy who refuted atheism by the argument from design. Between the extremes of orthodox belief and complete materialism there were the sceptics like Hume, but theirs is never a popular creed. So at that time most of the scientists in Great Britain and America were deists if not devout Christians, or else took little heed of such matters. It was in the nineteenth century that religious difficulties first became a serious issue and then the trouble only arose in an acute form in the field of biology.

Biology cannot claim theoretical advances at all approaching those of the physical sciences and the change in outlook since Franklin's day has been far less radical. There has been nothing to compare with the abandonment in the present century of the Newtonian conception of space and time. Before 1905 the difficulties were already formidable but it was taken for granted that the physical world could be thought of in terms of two distinct orders, spatial and temporal. Einstein's Special Theory of Relativity showed that we ought to think instead of a single space-time order. The Special Theory and the General Theory which followed it made radical advances in our understanding of physical events and the Quantum Theory was a landmark of even greater importance, but it was the merging of space and time which involved the widest issues, for it has changed our outlook on the whole significance of knowledge based on measurement.

In Biology, however, the disturbance to accepted habits of thought was of a more painful kind. It had been humiliating in the sixteenth century to be told that our world was not at the centre of the universe, and in the nineteenth Darwin's theory of the Origin of Species was as bad a blow to human pride. By denying the special creation of mankind it seemed to challenge the whole system of human values. And although few people now regard the theory of evolution as a challenge to their religious convictions, there are many who find great difficulty in accepting a theory which brings mankind wholly within the scientist's picture of reality. Even if we are ready to agree that the picture was there before the scientists uncovered it, the inclusion of our thoughts and feelings as well as our material activities raises misgivings. Freud and Jung have quieted some of them by

revealing the nature of the forces which determine our behaviour, but it is no great help to be told that our conclusions are largely irrational.

In spite of these ultimate difficulties the outlook for Biology has been immensely enlarged by all the advances which have taken place in the more exact sciences. The development of the cell theory gave a new turn to the whole conception of the living organism, and there has been a progressive development in the techniques for dealing with the complex and variable material which the biologist must study. At the beginning of the nineteenth century arguments of a statistical character are rare in medical or biological reports. Whether bleeding and purging was the appropriate treatment for a fever was argued from theory rather than observation with adequate numbers and controls, and later in the century Lombroso needed little but his impression of individual prisoners to convince penal reformers that criminals were a race apart, distinguished by the shape of the skull and other physical attributes.

Lombroso's criminal type was one of the many biological fancies that have not survived statistical treatment. Living organisms, even the simplest, are not identical and may never be fully expressed in numbers, but we have learnt how to check our impressions by numerical evidence. The study of inheritance became an exact science when Mendel's work was rediscovered and now even the actions of social communities are coming within the range of dispassionate measurement.

When Franklin asserted his admiration for the principles which he found in inanimate nature and his disgust for the animate and moral part, he was presumably contrasting the laboratory with the Council Chamber and meant no disrespect to physiology. Nor is there much evidence that his disgust was at all deep-rooted, that he could not enjoy human society in his old age as he had done in his prime. Cheerfulness seems to break through in his reflection that the balloon might "possibly give a new turn to human affairs. Convincing sovereigns of the folly of wars may perhaps be an effect of it; since it will be impracticable for the most potent of them to guard his dominions."

Few people then seemed to have had misgivings about the benefits which science was bound to bestow on mankind. Technical advances were beginning to cause widespread distress to those who had learnt traditional crafts and were too old to go to factories or emigrate, but the future good seemed certain to outweigh the present evil. There would be new sources of power, new materials to use and new lands to open up. For a time all was progress and no one had to think of its direction.

It is now clear enough that increased powers over the natural world will not give increased prosperity unless we can prevent them from bringing fresh dislocations in our society. In particular we must at all costs avoid the conflict of interests which leads to war, because its disasters have now become incalculable. We cannot avoid such conflicts if we have no idea where we are going.

So we have now this urgent appeal to the scientist to take an active part in planning for the future. Discoveries in the fundamental fields can scarcely be foreseen, but in the era of applied science a great deal of the effort of scientists is directed to the practical applications. Here there are greater opportunities as well as greater need for planning, for conserving natural resources, eradicating disease, improving food supplies and making the new sources of energy available where they are most needed.

And since we must think of the users as well as the products, the field of scientific investigation must cover our own behaviour. It must include the economic and social consequences of all the changes which may have come or may come from our greater control of nature. The Social Sciences have still to develop their techniques for investigating our reactions to one another. We cannot expect that the scientific diagnosis of social ailments will always produce the cure, part of our malaise may be incurable, but greater understanding of social consequences will certainly assist mankind to use its new powers without catastrophe.

Planning the applications of new discovery is now an urgent concern for a number of scientists far larger than the whole body of natural philosophers in Franklin's time and international co-operation is even more essential for this than it is for the consolidation of scientific theory. Since 1719 the Royal Society has had its Foreign Secretary to conduct correspondence with the Academies and learned men of other countries and science kept its international status in spite of the wars and blockades of the eighteenth century. It is only in recent years, however, that international planning in the application of scientific discoveries has become a major undertaking. We have to learn to plan and control the uses of science, without losing our freedom to direct our enquiries wherever discovery leads us.

How to preserve liberty in an ordered society has troubled statesmen and philosophers since the dawn of civilisation: if it must now trouble scientists too it is because since Franklin's time the structure of our society has been built up on scientific achievement.

". . . The rapid Progress *true* Science now makes, occasions my regretting sometimes that I was born so soon. It is impossible to imagine the Height to which may be carried, in a thousand years, the Power of Man over Matter. We may perhaps learn to deprive large Masses of their Gravity, and give them absolute Levity, for the sake of easy Transport. Agriculture may diminish its Labour and double its Produce; all Diseases may by sure means be prevented or cured, not excepting even that of Old Age, and our Lives lengthened at pleasure even beyond the antediluvian Standard. O that moral Science were in a fair way of Improvement, that Men would cease to be Wolves to one another, and that human Beings would at length learn what they now improperly call Humanity."

Letter to Joseph Priestley
Passy, February 8, 1780

STATES OF MATTER

BY

L. JANSEN [1] AND A. MICHELS [2]

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A universal property of matter is that it appears in three different states —solid, liquid and gaseous. These three states are associated with different ranges of temperature: as the temperature increases, a substance passes through the solid, liquid and gaseous states in succession. In the atomic interpretation of matter, the three states are associated with different intensities and different types of molecular motion. In this respect did the Renaissance bring the re-birth of ancient Greek thinking. It dates back to Leucippus, Democritus and Epicurus (about 400 B.C.), was rejected by Aristotle, but remained current to some extent. We find it back in great length in the poem "De Rerum Natura" by the Roman writer Lucretius (A.D. 55). The atomic structure of matter was in its ancient stage not based on convincing quantitative proofs characteristic of modern theories. During the middle ages it was among several alternative speculations, accepted by some, but emphatically rejected by others.

The revival of atomistics started around the middle of the seventeenth century with the work of Gassendi ("Syntagma Philosophicum," 1658). He appeared to be the first to realize that the motion of atoms alone was sufficient to account for a number of phenomena, instead of each phenomenon requiring a separate explanation. The importance of Gassendi's work was described as follows by Lasswitz ("Der Verfall der Atomistik im 17. Jahrhundert," Pogg. Ann., Vol. 153, p. 373 (1864)):

> Following Democritus and Epicurus, Gassendi in the seventeenth century re-established and elaborated on atomic theory based upon the assumption that all material phenomena can be referred to the indestructible motion of atoms and can therefore be described as *kinetic*. Gassendi's atoms are devoid of all qualities except absolute rigidity; they are similar in substance, but different in size and form, and move in all directions through empty space. On this basis Gassendi explains a number of physical processes, in particular the three states of matter and the transition from one to another, in a way very little different from that of the modern kinetic theory.

Hooke (1678), independently from Gassendi, attempted to give an explanation of Boyle's law for gases made up of atoms, but the first clear derivation of this law was presented sixty years later by D. Bernouilli in his book "Hydrodynamica" (1738). Bernouilli also attempted to find a relation between pressure and volume of a gas when the finite size of the

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molecules, which were supposedly absolutely hard and spherical, is taken into account.

After Bernouilli, the kinetic theory of gases made very little progress for about a century. Then a great many scientists such as Herapath (1821), Waterston (1845), Joule (1848), Kroenig (1856), Clausius (1857) and Maxwell (1859) took up the subject. Especially in the hands of Clausius and Maxwell the theory developed into its scientific mathematical stage. Other prominent contributors were, in the second half of the nineteenth century, Boltzmann and Kirchhoff, Tait and Lord Rayleigh, Lorentz and van der Waals.

At the close of the century, however, there had gathered, in the words of Lord Kelvin, "nineteenth century clouds over the dynamical theory of heat." The first of these clouds arose in connection with the problem of the constitution of the ether. The second one referred to observed deviations from a celebrated classical law in connection with the specific heat of gases and solids; this was the law of equipartition of energy. Whereas the experimental values at high temperatures were in agreement with this law, they decrease considerably as the temperature is lowered, and this phenomenon could not be understood.

These difficulties have been solved to a great extent in the new quantum theory of matter. It started in 1900, when Planck advanced the postulate that the vibrating particles of matter do not emit or absorb light continuously, but instead in discrete quantities of a magnitude proportional to the frequency of the light. With the help of this idea he showed that the results of experiments on the distribution of energy with frequency of radiation could be understood theoretically. In 1905 Einstein suggested that this minimum quantity of energy is not sent out in all directions in the process of emission of light, but instead unidirectionally, like a particle; such a particle of radiation energy is called a *photon*. Einstein also discussed the photo-electric effect and the laws of photochemistry. In addition, he applied the quantum idea to the heat capacities of solid bodies at low temperatures. This application to the specific heats of solids marks the beginning of the quantum theory of material systems.

In 1911, Rutherford discovered the constitution of the atom—it consists of a small heavy nucleus of positive charge and one or more extra-nuclear electrons. It soon became evident that the classical Newtonian laws of mechanics could not hold for the motion of electrons around the nuclei. Such moving charges had to lose their energy by radiation and the electrons would finally fall into the nuclei. The essential steps to solve these difficulties were taken by Bohr in 1913; he postulated that an atomic system can exist only in a number of non-radiating stationary states, each with a definite energy of the system. A transition from one stationary state to another is accompanied by the loss or gain of a definite amount of energy, which is emitted or absorbed as a quantum of electromagnetic radiation. The frequency of this radiation can be calculated by dividing the difference

in energy between the two states by a universal constant, introduced earlier by Planck. To obtain specific results for a hydrogen atom, Bohr proposed a simple rule for the selection of the stationary states; such a rule is called a "quantum condition" or a "quantization rule." A more general quantization rule was found by Wilson (1915) and by Sommerfeld (1916), which made it possible to apply Bohr's theory to a wider variety of atoms. Other essential contributions to the theory were added by Uhlenbeck, Goudsmit, and Pauli, and Bohr found a brilliant approximation for more complicated atoms. In this way he was able to explain the periodic system of the elements, discovered and formulated in the nineteenth century.

The work of Planck, Einstein and Bohr formed the basis of what is now called the "old" quantum theory. In spite of its successes in simple problems, it became evident around 1920 that the theory could not give correct quantitative results in the case of more complicated systems; among other difficulties, no one could see how to apply Bohr's theory to molecules or solids. For this reason the old quantum theory was finally abandoned in favor of what is known as quantum mechanics.

This new form of the quantum theory started with a fundamental hypothesis made by de Broglie in 1924. He postulated that there are waves associated with mechanical particles, a guess which was almost immediately confirmed by the discovery of electron diffraction by Davisson and Germer (1927), and by G. P. Thomson (1928). Once one knew that matter also had a wave-like character, there was a great body of theory ready to be used. Schroedinger (1926) had the brilliant idea of combining well-known wave theory with de Broglie's postulate. In the first paragraph of his paper "Quantisierung als Eigenwertproblem," presented to the Annalen der Physik, he stated essentially:

> In this communication I wish to show, first for the simplest case of the nonrelativistic and unperturbed hydrogen atom, that the usual rules of quantization can be replaced by another postulate, in which there occurs no mention of whole numbers. Instead, the introduction of integers arises in the same natural way as, for example, in a vibrating string, for which the number of nodes is integral. The new concept can be generalized, and I believe that it penetrates deeply into the true nature of the quantum rules.

It is said that Schroedinger wrote this publication after being asked to report on de Broglie's theory, which consisted largely of qualitative arguments at that time, in the colloquium at Zuerich, where he was a professor.

An alternative formulation of quantum mechanics had been developed by Heisenberg in 1925, in the first paper written on the new theory. Heisenberg did not use wave functions or wave equations, but instead developed a formal mathematical theory in which the physical quantities are expressed in terms of certain arrays of numbers known as matrices. This formulation has the advantage that it is more general than Schroedinger's, but it is difficult to use in the solution of problems of appreciable complexity. Schroedinger and Eckart (1926) showed independently that the two

formulations of quantum mechanics are mathematically equivalent. Shortly after that, with Heisenberg's "Uncertainty Principle" (1927) and Bohr's investigation of its implications (formulated as the "Complementarity Principle" (1928")), the formulation of the new quantum theory came to a preliminary close. The second half of this century has gone to the development of methods and results of quantum mechanics.

After this survey on the development of the atomic theory of matter, let us now return to the time around the eighteenth century and follow the growth of physical theories in a somewhat different direction. Whereas the fundamental question in atomic theory is connected with the structure of a single atom or molecule, we will now direct our attention to the behavior of large numbers of such atoms. The physical properties of compressed gases, of liquids and of solids are determined by the collective behavior of large numbers of atoms; in which way are these macroscopic properties related to the individual atoms? Do atoms and molecules exert forces on each other and if so, what is the nature of these forces?

In the early stage of atomic theory the atoms had no structure; they were simply point-masses, or absolutely rigid spheres, and could not be subdivided. They did not exert forces on each other, except those due to their rigidity. Bernouilli showed that a gas consisting of such "ideal" atoms obeyed Boyle's law. No further specifications were needed. Later it was realized that these assumptions were too elementary. If the atoms of a substance did not interact with each other, how could it then be explained that a solid substance resists compression? This resistance could only be understood in terms of repulsive forces between the atoms, when they are brought very close together. On the other hand, a solid also resists dilatation, so there must be attractive forces between the atoms, when they are pulled apart.

This realization that atoms and molecules exert forces on each other first entered the stage in connection with experiments on capillary action by Borelli and Jurin. They postulated the existence of attractive forces between the molecules in the fluid and the wall of the glass tube. Soon after that Clairault ("Théorie de la Figure de la Terre," Paris, 1743) pointed out that these forces must be general, not only causing surface tension, but applying to all molecules, although different in intensity between different kinds of molecules. From then on, different theories of general form, not specifying the precise character of the forces, nor their origin, followed in quick succession. All through the nineteenth century, however, it was believed that these forces were unique, that they existed in addition to the Coulomb law of attraction and repulsion between electric charges and that they had a much smaller range but a greater strength within that range. The exact form of the interaction did not matter, since experimental results were not accurate enough to distinguish. Laplace ("Théorie de l'Action Capillaire," Paris, 1806) provided the first mathematical theory of intermolecular forces. He proved that if the forces act along the lines joining the molecular centers, and if they were of short

range, they would result in a surface tension which depended on the curvature of the surface as observed. This theory was later refined by Gauss (1830), but Maxwell was the first who attempted a specific analytic form for the interactions. He concluded from rather inaccurate experiments on diffusion velocities and viscosity of gases that the forces were repulsive, and that they were proportional to the inverse fifth power of the distance between the molecules (1868). These conclusions have not been substantiated later, and even at the time they stood in definite contradiction with the results of experiments performed by Joule and Kelvin (1853). These scientists devised their famous "porous plug" experiment in order to test the existence or non-existence of cohesive forces in a gas. A quantity of a gas of specific pressure and temperature was let to expand through a porous plug into an empty container. The temperature of the arriving gas was then carefully measured. If the molecules of the gas did not exert forces on each other, then the kinetic theory predicted no difference in temperature between the two chambers, whereas a decrease in temperature would point to the existence of cohesive forces. Earlier experiments by Gay-Lussac and Joule had failed to detect any temperature change in the gas, showing that the forces of cohesion were at least very small. The more precise experiments by Lord Kelvin and Joule, however, established definitely the existence of a slight temperature change, thus proving that cohesive forces exist. The cooling was largest in the case of carbon dioxide, which showed that this gas is far from "ideal" or "perfect." For hydrogen molecules a very slight increase in the temperature was observed; Regnault described this gas therefore as "plus que parfait." It then became clear that a real gas differs from the concept of an ideal or perfect gas in at least two respects. The molecules which in the ideal gas were treated as spherical "points" must have size and shape, and the cohesion forces which were supposed to be absent in the ideal gas could not be neglected. Therefore all theoretical equations referring to these ideal gases had to be changed to take into account the two new factors.

The best-known correction of this type was given by van der Waals in his famous essay "On the Continuity of the Liquid and Gaseous States" in 1873 (published originally by Sigthoff, Leyden). Without specifying his forces any further than to regard them as attractive, van der Waals succeeded in deriving his equation of state (the relation between pressure, volume and temperature). Through his conception of the forces between molecules, he deepened the understanding of many phases of physics and chemistry. As a tribute to his fundamental work, the cohesion forces are usually referred to as "van der Waals forces."

The quest for an explanation of van der Waals forces in terms of more basic concepts did not make great progress until about 1920, when Debye (1920) and Keesom (1921) tried to interpret them as resulting from orientation and induction effects between permanent and induced electric dipoles and quadrupoles, which may occur if the electronic charges in a molecule are not distributed with spherical symmetry. The orientation effect

(Keesom) had to be discarded, however, since the theory predicted that van der Waals forces would decrease with increasing temperature, which is not the case. The induction effect (Debye, Falkenhagen) did not show this behavior, but it could not possibly incorporate the explanation of van der Waals forces between atoms of the rare gases, since the charge distribution in such atoms should have spherical symmetry.

It thus became apparent that an essential effect for the explanation of intermolecular forces was missing. Here, again, quantum mechanics provided the final solution. A first indication of such an explanation appeared in a paper by S. C. Wang (1927), who calculated with quantum mechanical means the energy of interaction between two hydrogen atoms for large interatomic separations (large compared with the average distance between an electron and its nucleus). London, in 1930, realized the full meaning of these forces and derived formulae for their calculation. He also drew a parallel between the nature of intermolecular forces and the phenomena of optical dispersion; therefore these forces are often called "dispersion forces." London's calculations, based on quantum mechanical methods, form the basis of our present knowledge of van der Waals forces. A physical meaning (which should not be taken too literally) for these forces may be given as follows: consider two hydrogen atoms, each with one electron, at a considerable distance from each other. Although the distribution of charge in each atom has spherical symmetry on the average, the electron and the nucleus form a permanent electric dipole at each particular instant of time. This induces a dipole in the other atom and the induced dipole tries to assume a direction parallel to the direction of the inducing moment. The interaction between the two dipoles is a net attraction, when averaged over all the orientations of the inducing moment.

During the past two or three decades, a considerable amount of knowledge has been gathered regarding van der Waals forces. Also the repulsive interactions between atoms or molecules, which prevail when the atoms are very close together, have received a quantum mechanical explanation, although our knowledge in this region is much more limited. The latter difficulty has a peculiar origin. In general, quantum mechanical calculations for the interaction between atoms or molecules are less complicated for large distances between the atoms or molecules than for small distances. This is because in those calculations one usually starts from the situation of isolated, that is non-interacting, atoms and then approaches the actual state of the system in a number of steps. For large distances this number will be small, since the interaction will only be very weak and therefore the actual situation differs only very slightly from the state of isolated atoms. For small or intermediate distances, however, the starting point of isolated atoms is in general not a good basis for the calculations, except if the electrons are very rigidly bound, such as in the case of atoms of the inert gases.

Instead of trying to find the interactions between molecules by direct quantum mechanical computation, often an empirical method is followed. This starts with an *ad hoc* assumption about the form of the interaction,

and tries to find values for the parameters in this analytic expression from a statistical calculation of some physical property of gases and solids (or the two combined), and a comparison with experimental data. Here, however, we meet with serious difficulties. Suppose we choose deviations from Boyle's law of dilute gases as our empirical basis for the evaluation of intermolecular forces. In such a dilute gas it will not happen often that two atoms are very close together; on the average the atoms will be a considerable distance away from each other and at such large distances their interaction will only be very weak. It follows that the measured effect will be small. This in turn implies that information about intermolecular forces obtained in such a way will only be very vague, unless the accuracy of the experiments can be increased tremendously. This method has indeed been followed, but the technical difficulties are enormous. A better possibility would seem to lie in measurements at higher densities, but in this region the statistical description of the system becomes increasingly more complicated. One of the main difficulties lies here in the description of correlated motions of the atoms. Whereas in a gas the atoms move to a large extent unhampered by the presence of other atoms, their motions in a liquid are more or less correlated, at least those of neighboring atoms or molecules. One may say that in a liquid a short-range ordering has taken place. In a solid, this ordering process is much more extensive: besides one of short range, we have here also a long-range order. To describe the physical behavior of such a system, one starts from the state of completely uncorrelated motions (the ideal gas, or the perfect classical crystal at absolute zero temperature) and approaches the actual state of the system in a number of steps of increasing degree of correlation. If in the final state the degree of correlation is high, then the number of steps in such a procedure is large and the formalism becomes mathematically too complex. This is also a reason why we cannot actually "prove" theoretically that a gas exhibits the phenomenon of condensation upon sufficient decrease of the temperature, and then crystallizes.

We have mentioned earlier that in the nineteenth century the intermolecular forces were considered as having a unique origin, unrelated to any forces which were known at that time. In this sense the final explanation of these forces was somewhat of an anti-climax: they were shown to be the result of well-known interactions between electrical point-charges; the law of force between electrical charges is at the basis of all theories on the interactions between atoms and molecules. This law was formulated late in the eighteenth century by Coulomb (1736–1806). With the help of his ingenious torsion-balance, invented about 1784, he found that the repulsion between two small, similarly electrified spheres varies inversely as the square of the distance apart of their centers (published in the "Mémoires de l'Académie Royale des Sciences," 1784). Later, in a second publication in 1785, Coulomb described his investigation of the law of attraction between charges. With Coulomb, the first stage of the theory of electricity after the Renaissance ended.

"At length we are in Peace, God be praised, and long, very long, may it continue. All Wars are Follies, very expensive, and very mischievous ones. When will Mankind be convinced of this, and agree to settle their Differences by Arbitration?"

Letter to Mrs. Mary Hewson
Passy, January 27, 1873

THE COMING OF AGE OF THE ATOM *

BY

LOUIS LEPRINCE-RINGUET [1]

Académie des Sciences

It is only since the end of the last century that the atom has become a precise concept, unveiling its complexity progressively until it appeared to us in all its splendor in a revelation of the considerable power contained in its nucleus.

Of course, it would be idle to think that all is now known about the nucleus. The apparent simplicity of its constitution of protons and neutrons conceals formidable mysteries; and the creation of "strange particles," the heavy mesons and the hyperons, by collisions at high energy of the constituents of the nucleus itself gives us glimpses of problems of a singular complexity.

The idea of a nucleus was not reached very soon after the first experiment of Becquerel in 1895 which was basic to the discovery of radioactivity. A whole series of studies was necessary to formulate the first concept of the nuclear atom. Then a new plateau had to be crossed to define this nucleus more precisely by its exterior aspect: that is, by its mass, electric charge, dimensions and the surrounding field of force. But it appeared at that time as a simple, indivisible particle, and only the natural radioactive elements gave some indication of the nature of an inner structure. Finally, the first artificial transformation, a prelude to an immense revolution, was discovered. However, some ten more years were to pass before the truly explosive expansion of this science got under way. For refined techniques, in particular that of the accelerators, were then under development; and it may be said that it was thanks to their improvement beyond certain limits that construction of most of the devices indispensable to good observation of particle phenomena was made possible.

So, about 1930 with the appearance of electronic counters, selectors, proportional amplifiers and with improvements in the Wilson chamber, the physicist had available a new dimension to observe atomic particles. Then discoveries followed one another in rapid succession. One of the first, and perhaps the most important, was that of the neutron which almost immediately took first rank among the constituents of the nucleus and was used shortly after with extraordinary success as a projectile for nuclear

* Manuscript submitted in French.

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bombardment. A long series of experiments established a general principle from these phenomena: that all nuclei might be attacked by suitable projectiles and be transformed into neighboring nuclei with the emission of particles or electromagnetic radiation. Also, the basic discovery of artificial radioactivity was made: when using all the isotopes of all the elements, new unstable nuclei must be formed by such a diversity of nuclear bombardments since the number of stable nuclei is in fact quite limited.

Knowledge of the internal nuclear structure now became marvellously precise: all nuclei might be constructed with protons and neutrons. But, at the same time, this extraordinary simplification was accompanied by an awareness of new problems—that of the nuclear field being particularly acute. How, in a space as limited as that of a nucleus, could the constituent particles, the protons and neutrons (now called nucleons), remain tied? How could they have a cohesion assuring the stability of the structure? What are the forces acting among the nucleons keeping them bound? These forces are intense at very short distances and must become negligible as the distance between the particles increases since the nuclei keep their cohesion even when a projectile comes near. The classic law of Coulomb remains valid up to distances of the order of 10^{-12} centimeter from the nucleus, so the nuclear forces must be ineffective at radii of action of this order.

Next the meson, a particle observed in cosmic radiation, comes into the picture. It represents the particle aspect of the nuclear field as the photon represents the particle aspect of the electromagnetic field. Here is the point of departure for a considerable number of studies of the nuclear field and the organization of the nucleons in the nucleus. This wave of research is, moreover, far from diminishing at present; rather it has been intensified from year to year as new problems appear with each experimental discovery or each theoretic synthesis.

By about 1938, after some feverish years, a considerable number of facts about the constitution of the nucleus had been unravelled. Then, just on the eve of the Second World War, a new phenomenon appeared a little apart from the usual nuclear reactions—the fission of uranium by slow neutrons. A new period of knowledge is opened: for the first time hope for an application of nuclear science to industry and explosives may be entertained thanks to the excess of neutrons produced by fission.

THE PIONEERS: HENRI BECQUEREL, PIERRE AND MARIE CURIE

But to return to the first discoveries, in particular to the curious one made by Henri Becquerel in 1895—it is well known that uranium salts clouded some photographic plates in a drawer. Becquerel was surprised that this occurred in the darkness of the drawer. He was interested in the recently discovered Roentgen rays which fluoresced in the glass tube in which they were produced and was trying to discover whether luminescent bodies exposed to light were capable of emitting rays analogous to X-rays.

The uranyl salts already studied in his laboratory were selected and exposed to sunlight. Photographic plates were placed in darkness near them. The experiment demonstrated that rays had been emitted even though the material was sheltered from the energizing light: it was the discovery of radioactivity. Then it was easy to show that the spontaneous activity of uranium is an atomic property and not a molecular one, a proof that the radiation comes from a region of the atom unaffected by chemical reactions. Here was the action of the uranium nucleus, but at that time physicists were still very far from the concept of a nuclear atom.

Pierre and Marie Curie made the second step when studying uranium ores yielding a radioactivity abnormally high for their uranium content. This was explained by the presence in the ore of very minute quantities of an unknown and highly radioactive substance: polonium and then radium were discovered. At this time the first radiation burns were noticed, and utilization of radioactive substances to destroy harmful cancer cells was suggested.

One of the important discoveries of Pierre Curie and Laborde deals with the heat released by radium: the amount released by one gram of this element per day is low, but the production of energy continues for thousands of years until the atoms are completely transformed into atoms of lead and helium. The total amount of heat produced by one gram of radium may be calculated to be equivalent to that furnished by the combustion of 400 kilos of coal.

This was one of the first experimental indications of the considerable power which might be furnished by the energy contained in the nucleus; but it was only forty years later that man succeeded in releasing part of this energy at will.

LORD RUTHERFORD AND THE NUCLEAR ATOM

Many of the problems raised by radioactivity were studied and solved by Rutherford and his school. In particular, the theory of successive disintegrations which occur as radioactive materials evolve was formulated in 1903, and the disintegration constant of each element was fixed. This table remains today the foundation of all nuclear physics.

But one of the most remarkable ideas of Rutherford was to use the alpha rays emitted by radioactive bodies to try to probe the immediate vicinity of the atom in order to explore the surrounding field of force. These were the very famous experiments on the deflection of alpha particles by matter which established the existence in each atom of a region of very small dimensions with a positive electric charge dependent on the nature of the element. With the aid of his students, among whom Niels Bohr must be mentioned, he was led to construct the classic model of the atom with a central nucleus surrounded by electrons. The model, known as the Rutherford-Bohr atom, postulates a positive charge of the nucleus equal to that of

the satellite electrons. This charge corresponds to the atomic number; and the experiments of Moseley, Rutherford's student, confirmed the increase of this number as one rises in the natural classification of the elements. In short, in 1913, the laws of radioactivity, transformations of radioactive nuclei, and radiations emitted were well known; and in addition, thanks in particular to the alpha particles, a remarkable definition of the nuclear atom had become possible.

ISOTOPES

During this period the physicists intensified their efforts, and several very remarkable devices which were to bring much knowledge of the atomic world were perfected. The mass spectrograph which weighs atoms by passing them through suitable magnetic and electric fields is well known. Developed by J. J. Thomson and Aston, and then greatly improved by numerous physicists who achieved difficult measurements with it, this apparatus made possible the determination of the isotopes of the various elements. A chemical element is not formed of atoms of identical nuclei; chlorine, for example, contains in constant proportion atoms of different nuclei with masses, respectively, of 35 and 37. These are the two isotopes. Almost all the elements are composed of several isotopes, tin having 10. Artificial transmutations and fission have disclosed many others which do not exist naturally and are radioactive.

Among the remarkable tools special mention should be made of the Wilson chamber. Thanks to it it has been possible to photograph the tracks of fog formed by the ions released by a particle in rapid motion. When a fast electron, for example, passes through the gas of a Wilson chamber which is oversaturated with water vapor, the ions produced are shrouded in droplets of fog from the condensation of the gas. High speed photographs of these trajectories show the path of the fast particle. Further, by placing screens in the path of the rays to be studied, the effects produced on matter may be ascertained; and by the use of a magnetic field capable of bending the trajectories in proportion to their speed, precious information is obtained about the sign of the particles and their general behavior. Important improvements due to the coupling of electron counters and Wilson chambers by the ingenious method of Blackett and Occhialini produced condensation by the passage of the ray itself so that the Wilson chamber has become a marvelous instrument for the exploration of fast atomic particles. The list of discoveries due to this apparatus is considerable—Carl Anderson discovered the positive electron and identified the meson in cosmic rays; the phenomena of the creation of pairs of electrons were observed and studied.

New techniques have now been developed (diffusion chambers, bubble chambers) which will further increase the possibilities of the Wilson chamber, and we can expect much from the results to be obtained shortly from this refinement.

QUANTA, RELATIVITY AND NUCLEAR PHYSICS

In a more theoretical domain the introduction of quanta and relativity modified and made more precise the fundamental notions of physics. It is known that Planck's quantum theory elaborated by Niels Bohr permitted the clarification of the nature of light rays emitted by atoms. But in fact, a true revolution has occurred, and the theory is bringing about a deeper and deeper comprehension of the nucleus as it gradually dominates atomic science. The same situation obtains for the theory of relativity. Its conception was in no way concerned with the nucleus, but almost immediately there appeared as a direct consequence of the theory the idea of the identity of mass and energy which has become for nuclear physics a most rigorous law. The mass of the atom is contained, in fact, almost entirely in what will be defined later as the nucleus, and all nuclear reactions involving considerable amounts of energy must respect Einstein's relation: variations of mass of the constituent parts will correspond very exactly to the energy involved. The relation mass-energy becomes the precision balance of all nuclear reactions—in the creation of new elements, in the determination of the stability of the nuclei, in the prediction of nuclear reactions, it is infallible. Further, now that certain particles have been created, such as electron pairs and mesons, the relation mass-energy obtains absolutely, permitting the accurate prediction of possible creations and disintegrations.

THE NEUTRON AND THE CONSTITUTION OF THE NUCLEI

Rutherford first discovered artificial transmutation in 1919 by using alpha particles from radioactive substances as projectiles. This was truly the beginning of modern nuclear physics. In the following years this experiment was extended to aluminum and to numerous other elements proving that in certain cases one could liberate from the nucleus of the atom part of the intra-nuclear energy so powerfully used later. But to his death in 1936, Rutherford doubted that this energy could be used on a large scale.

An event of first importance was the discovery of the neutron which was made in three steps beginning with the first experiments of Bothe and Becker, extended by those of F. Joliot and Irene Curie and terminated by those of Chadwick. The radiation resulting from the bombardment of beryllium with alpha particles was composed of neutral particles of a mass similar to that of the proton. This new particle—the neutron—evoked much experimental and theoretical research. In particular, the physicists of Rome under the direction of Fermi entertained the possibility of producing nuclear transformations with neutrons. Also, the importance of slow neutrons was discovered: these particles impelled at very slow speeds by collisions of light nuclei are remarkably effective to attack the nucleus. Clearly the neutron has exceptional ability to penetrate the nucleus since the potential barrier surrounding the latter does not exist for it.

The neutron was recognized, moreover, almost immediately as one of the fundamental constituents of the nucleus; and Heisenberg formulated the hypothesis, audacious at that time, that the nucleus was composed only of protons and neutrons. Why spontaneous disintegrations did not supply the basic constituents of the nucleus was successfully explained, and the hypothesis proton-neutron was gradually confirmed. These two nucleons are present in almost equal number in light nuclei, the excess of neutrons becoming greater as one progresses toward the heavier nuclei—uranium 238 contains 92 protons and 146 neutrons. This excess of neutrons in the stable heavy nuclei is explained in a valid way by the influence of the repulsive electrostatic field of the numerous protons of such a nucleus.

At the same time artificial radioactivity was discovered by Joliot and Irene Curie. The reactions of transmutations are very numerous and often give rise to unstable nuclei which return to the normal state by the emission of a positive or negative electron. So it is possible to manufacture artificial radioactive substances (it is done now with piles or accelerators) which are extremely useful in many fields. They are the celebrated tracer elements whose use is being developed considerably today.

THE NUCLEAR FIELD, THE MESON

The presence of protons and neutrons in a nucleus raises difficult problems: these particles are strongly tied in stable nuclei and can escape only in the very violent collisions of nuclear transformations. Now the forces uniting these particles so tightly can be neither gravitational nor electromagnetic. A new force must be introduced which will be evidenced by a new form of field quite distinct from the only two known up to then. This nuclear field must be the bond among the constituents of the nuclei: it assures their cohesion and is effective only at extremely reduced distances of the order of the radius of the nucleus. With this field must be associated a particle representing its particle aspect as the bullet of light or photon represents the electromagnetic field. About 1936 Yukawa first defined these particles and attributed to them a mass two hundred times that of the electron. The experimental meson of cosmic rays and the theoretical meson introduced by Yukawa were perhaps not exactly the same at that time. Later research has shown the complexity of these assumptions and has also proved that the nuclear meson is created in reactions at high energy just as the photon of light is created by reactions among charged particles.

In the domains of theory and experiment considerable research is still being carried on for a better knowledge of the nuclear field. The wave theory advanced by Louis de Broglie in 1924, then restated in principle by Heisenberg under another aspect and developed mathematically by Schrödinger, has contributed remarkably to an understanding of the relations among the fields and the particles, of the levels of energy, and other funda-

mental ideas. It exercises a very profound influence on the development of nuclear physics.

The first period of the Atomic Age ends in 1938 with the discovery of the remarkable phenomenon of the fission of uranium. Another world is opened to the physicist. No longer is the concern basic research alone, science and industry with their immense allied possibilities come into the picture. Now the possibility of releasing the energy of the nucleus impinges on all aspects of the affairs of great nations. But this expansion was prepared by the first fifty years of basic research whose principal steps we have just briefly related.

". . . Dr. Priestley you tell me continues his Experiments with Success. We make daily great Improvements in *Natural*, there is one I wish to see in *Moral* Philosophy; the Discovery of a Plan, that would induce & oblige Nations to settle their Disputes without first Cutting one another's Throats. When will human Reason be sufficiently improv'd to see the Advantage of this! When will Men be convinc'd, that even successful Wars at length become Misfortunes to those who unjustly commenc'd them, & who triumph'd blindly in their Success, not seeing all its Consequences."

Letter to Richard Price
Passy, February 6, 1780

BENJAMIN FRANKLIN AND ONE PLUTONIC YEAR

BY

HARLOW SHAPLEY[1]

American Academy of Arts and Sciences

Two hundred and fifty years ago the planet Pluto was in Leo and Benjamin Franklin was born. The planet Pluto is now again in the Lion, after a circuit of the zodiac, and Benjamin Franklin's birth is being celebrated. The Pluto-in-Leo occupancy has occurred four times every millennium, for the past million years and more. In the future, for an indefinite number of millions of terrestrial years, these long Plutonic years will unfold. The circuit of Pluto around the sun that is just completed is of no particular significance celestially—no better nor worse than those ancient Plutonic years when the Rocky Mountains were yet unborn and Brontosaurus roamed the land. But in the history of humanity, and especially of human technology, this most recent revolution of our remotest known planet is the greatest that has ever happened. A reference to what was known about the outside universe at the time of Franklin's birth and what is now known will illustrate the steady rise of science in this most recent of the Plutonic years.

What a tiny science astronomy was in 1706! It was small in reach, primitive in its tooling, and in comparison with the wide reaches of current astrophysics, geophysics, radio astronomy, and the cosmogony of galaxies, it was extremely limited in its content of observational fact. But in no sense was astronomy then a small enterprise relative to other fields of science, and its penetration in the hands of Sir Isaac Newton into the fundamentals of celestial mechanics remains an undying source of amazement and admiration.

To be sure, we have added much during this past Plutonic year to our knowledge of the planets and of celestial mechanics. The great works of Lagrange, Laplace, and Leverrier (keeping to one nation and one initial letter) did much to broaden and deepen the epoch making contributions of Newton. Since Franklin's birth three of the nine planets of the sun's family have been discovered, as well as many new satellites, and all of the 1600 known asteroids. Much work has been done on the theories as well as on the observation of meteors and comets.

Nevertheless, the solar system had been fairly well comprehended by 1706, thanks to the scientific revolution of the sixteenth and seventeenth centuries highlighted by Copernicus, Galileo, Tycho, Kepler, Newton, and

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Halley, and in this communication I shall emphasize chiefly the advances in stellar and galactic astronomy since the birth of Franklin.

At the outset one is struck again by the relative newness of all science in Franklin's day in contrast to the great maturity that had been obtained at that time in the arts and literature. We can scarcely claim that the knowledge of humanity demonstrated by Shakespeare and his contemporaries has been surpassed in these days, notwithstanding the modern psychological adventurers; nor do we claim, even in our most daring moments, that painting and sculpture now transcend that of the past. But in all fields of science, almost without exception or question, each decade surpasses the preceding—not in outstanding personalities, of course, but in the sum total of knowledge and concrete accomplishment.

Benjamin Franklin and Immanuel Kant were contemporaries—one the great practical philosopher of the new world, the other the highly metaphysical philosopher of the ancient teutonic culture. The sun, moon, and planets were of interest to Franklin for almanac making and in the practice of navigation, but there is little record of his concern with the stars or with cosmology. On the other hand Kant was exceedingly sensitive to the sidereal world and its meaning for the mind of man, although it concerned his physical being, his thrift, his immediate social problems not at all.

In these days of much knowledge of the stars, nebulae, galaxies, and the metagalaxy in an expanding sidereal universe, we are all quite aware of the nature of the Milky Way, and the identification of certain nebulae as external galaxies. But our accurate and accepted information on this subject is but a generation old. The universe we explore is a twentieth century universe. We are definitely proud of our conquest of so much of the sidereal unknown. It is healthy to remember, therefore, that in Franklin's middle age and Kant's youth there were already one or two minds who devised and accepted as highly possible their own concept of galaxies as separate stellar units in the vast oceans of space.

These galaxies, these other Milky Ways, were recognized in the early telescopes only as faint patches of light that did not resemble isolated stars.

Just two hundred years ago, following a tip about the nature of the Milky Way published by the semi-mystical Thomas Wright of Durham, the young philosopher Kant did some astronomical speculating. His surmises are too little known at the present time, and therefore some quotations from W. Hastie's translation of Kant's "Universal Natural History and Theory of the Heavens; or an Essay on the Constitution and Mechanical Origin of the Whole Universe Treated According to Newton's Principles" are offered to illustrate the most advanced thought of Franklin's day on the nature of the material universe.

> . . . If a system of fixed stars which are related in their positions to a common plane, as we have delineated the Milky Way to be, be so far removed from us that the individual stars of which it consists are no longer sensibly distinguishable even by the telescope; if its distance has the same ratio to the distance of the stars of the

> Milky Way as that of the latter has to the distance of the sun; in short, if such a world of fixed stars is beheld at such an immense distance from the eye of the spectator situated outside of it, then this world [our galatic system] will appear under a small angle as a patch of space whose figure will be circular if its plane is presented directly to the eye, and elliptical if it is seen from the side or obliquely. The feebleness of its light, its figure, and the apparent size of its diameter will clearly distinguish such a phenomenon when it is presented, from all the stars that are seen single.
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> We do not need to look long for this phenomenon among the observations of the astronomers. It has been distinctly perceived by different observers. They have been astonished at its strangeness; and it has given occasion for conjectures, sometimes to strange hypotheses, and at other times to probable conceptions which, however, were just as groundless as the former. It is the 'nebulous' stars which we refer to, or rather a species of them, which M. de Maupertuis thus describes: 'They are,' he says, 'small luminous patches, only a little more brilliant than the dark background of the heavens; they are presented in all quarters; they present the figure of ellipses more or less open; and their light is much feebler than that of any other object we can perceive in the heavens.'
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> . . . It is . . . more natural and conceivable to regard them as . . . systems of many stars, whose distance presents them in such a narrow space that the light which is individually imperceptible from each of them, reaches us, on account of their immense multitude, in a uniform pale glimmer. Their analogy with the stellar system in which we find ourselves, their shape, which is just what it ought to be according to our theory, the feebleness of their light which demands a presupposed infinite distance: all this is in perfect harmony with the view that these elliptical figures are just universes and, so to speak, Milky Ways, like those whose constitution we have just unfolded. And if conjectures, with which analogy and observation perfectly agree in supporting each other, have the same value as formal proofs, then the certainty of these systems must be regarded as established.
>
> . . . It might further be conjectured that these higher universes are not without relation to one another, and that by this mutual relationship they constitute again a still more immense system.

Franklin presumably did not know of the cosmologic ideas of Wright and Kant. The later classics on Reason, the major work of Kant, were little known in America in Franklin's time or among the diplomats of England and France with whom he associated in his later life.

At the end of the eighteenth century Sir William Herschel and others awakened much interest in the distribution of stars and incited speculation on the nature of the Milky Way. In the latter half of the nineteenth century the popular writers on astronomy used the term "external galaxy" for the high latitude nebulosities and made a good deal of the concept of "island universes." It was much later, however, when the professional astronomers, on the basis of steadily accumulating data on the positions, numbers, colors, brightnesses, and motions of the stars, began the authentic unraveling of galactic structure.

The eighteenth century astronomers made catalogues of the brighter stars, developed instruments for that work, exploited the mathematical niceties of celestial mechanics, extended Newton's interpretation of the tides (Euler), discovered the aberration of light (Bradley) and thereby sub-

stantiated Roemer's discovery that its velocity is finite. They observed the eighteenth century transits of Venus in the interest of a better determination of the solar parallax. If Franklin's autobiography had covered another thirty years we would have doubtless learned of his reaction to some of these mind-lifters, these high-lights in the exploration of the universe. Franklin was in Europe, for instance, when Halley's comet returned and in the exciting days when Herschel discovered Uranus and named it for his "gracious and magnificient" monarch, George III. But Benjamin Franklin then as earlier was much more concerned with the concrete problems of his fellow men than with the abstract problems of remote planets and stars.

Our present knowledge of the sidereal universe would require volumes for proper presentation. It suffices for this comparison to list some of today's conquests, and a few of the outstanding concepts, that now are heavily backed by competent observation. They were all absent from the thoughts of eighteenth century observers and thinkers.

1. The periodic table of the chemical elements and its underlying atomic theory.
2. The concept of photons.
3. Discovery of natural radioactivity, and eventually the production of artificially radioactive atoms followed by their beneficent use in medicine.
4. The isolation, weighing, and practical use of electrons, protons, and other "fundamental" particles of matter.
5. The Mendelian laws of heredity and their application to human welfare by way, for instance, of hybrid corn.
6. The creation of the sciences and arts of bacteriology, aeronautics, electronics, statistics, relativity, and to get nearer to our principal theme of "The Universe," the development of spectroscopy, photography and optical engineering which have made us familiar with trillions of stars, millions of galaxies, and a mighty universe which expands and reduces man to a peripheral ephemeral with nevertheless a king-size probing mind.

Another great contemporary of Franklin was Edmund Halley (1656–1742). He did the magnificent public and scientific service of getting Newton to complete and publish the *Principia*—one of the half dozen greatest books of all time. No one much remembers that Halley succeeded the great pioneer Flamsteed as the second Astronomer Royal, but his name has become a common household word due to his working on the career of a comet that appeared in 1682. It stands as one of man's fine triumphs of the mind—Halley's prediction that this comet, after remaining in the outer part of the solar system far beyond telescopic reach for about 75 years, would be seen again in the sun's and earth's neighborhood in the 76th year—that is, in 1757 or 1758. Thus Halley and his fellow calculators of celestial motion had found, in the early years of Benjamin Franklin, that comets are bodies of the solar system, moving in elongated orbits in accordance

with Newton's gravitational laws. Comets joined moon and planets and falling apples in taking the supernatural out of nature. Cause and effect had gone heavenward.

On the occasion of his first visit to England as a teen-ager, Franklin expressed the desire to meet with the great and aging Sir Isaac Newton. But apparently the opportunity did not come his way. He met many other of the great men of Europe during his lifetime and gradually became recognized as a great scientist, much honored in England and France as well as at home. The catholicity of his interest and the magnitude of his accomplishments were the pride of his century. In our century, if the custom of formal and routine education had not incapacitated him, he would have shone as our most luminous scientist and humanitarian. For, as a scientifically minded and diplomatic operator in a world that needs judicious inquiry and dissent, Franklin had what it takes.

". . . God grant, that not only the Love of Liberty, but a thorough Knowledge of the Rights of Man, may pervade all the Nations of the Earth, so that a Philosopher may set his Foot anywhere on its Surface, and say, 'This is my Country.'"

Letter to David Hartley
Philadelphia, December 4, 1789

PIONEERS IN ELECTRICAL COMMUNICATIONS *

BY

ELIGIO PERUCCA [1] AND VITTORIO GORI [2]

Accademia delle Scienze di Torino

Perucca was seated at his desk thinking about this paper and waiting for his friend and co-author, when an old gentleman entered the room with an authoritative air.

"Professor, allow me to introduce myself: Polybius, the son of Lycortas, an historian of the second century, B. C."

"I am very honored, Mr. Polybius. To what do I owe the honor of your visit?"

"You are about to write an article on the pioneers of electrical communications. I should be very grateful to you if you would remember us, who believe we were truly pioneers of telegraphy. Think of the alphabetical code for visual signalling, described in my Ιστοριας. You see, I am talking to you in the name of the syndicate of ancient communications, of which, by the trust the entire group placed in me, I am President."

"But," interrupted Perucca, "I see that you are well informed about our work; therefore, you probably know that we are going to write on pioneers of *electrical* communications."

This time it was Polybius who interrupted.

"Will you speak about kilometer, meter and centimeter waves, along with communication by radio?"

"We shall mention them, but only briefly," answered Perucca.

"Exactly," he continued, "and now that so much is known about the nature of light, won't you want to touch briefly upon radio communication using extremely short microwaves?"

Perucca was about to argue this point, when Polybius disappeared. Professor Gori had entered the study and Perucca had awakened with a start.

We are beginning badly, if we mix dreams with history!

THE BEGINNING

The twenty-year period from 1729 to 1748 was characterized by an increasing number of experiments on the transmission of "electrical fire." It

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seems natural, therefore, that someone in that period would have thought of using the wondrous properties of this "fire" for electrical signalling at a distance. Such a thought is attributed to Benjamin Franklin [3] and even though his attempt—a line four miles long (6.5 km)—failed, perhaps because of defective insulation or perhaps because the electrostatic condensers were too weak, this did not detract from the importance of the idea.

But electrical signalling without a code is not telegraphy; the use of an alphabetical code for transmission of a language had been proposed by Polybius in an era when long distance transmission was limited to the use of a few torches. Since at least one other alphabetical code is known to have existed prior to that of Polybius, one must bear in mind that the latter only modified it.

In the transmitting station, two groups of three and eight torches (or similar fires) formed two clusters of three and eight lights, respectively; when kindled fully or partially in all possible combinations, they provided twenty-four distinct signals, as many as there were letters of the alphabet (Julius, The African). Polybius proposed the use of two clusters of five lights each, and from them he got twenty-five signals, using only ten lights.

The practical need to use a code for alphabetical transmission was not ignored by many pioneers in electrical communications. For example, the anonymous C. M.,[4] to whom the first project on electrical alphabetical communication is attributed (the pithball telegraph), used as many separately insulated wires as there are letters of the alphabet. This multiplicity of wires rendered practically useless not only this particular method of transmission, but all similar many-wired systems developed during the next three-quarters of a century, even after the advent of galvanic electricity in which the electric current is generated by Volta's pile.

In the 80 years following C. M.'s proposal, we acknowledge only two essential achievements in telegraphy.

In the first experiments already referred to, "electrical fire" seemed capable of an infinite velocity. The idea must have been unacceptable to many, and although it had been known for some time past (Ole Rômer, 1675) that the velocity of light was very great, no one seems to have recognized the relationship between the velocity of light and that of electricity. This would have explained the "infinite" velocity experimentally found for the electrical fire.

The concept of infinite velocity was certainly not accepted by James Alexander, who in 1756 suggested to Franklin that the electrical experiments be repeated, using a thousand-mile line instead of the short lines which had been used previously.

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[3] Cf. G. L. ARCHER, "History of Radio to 1926," New York, The American Historical Society, Inc., 1938, p. 11 and note 8.

[4] "An Expeditious Means of Conveying Intelligence," *Scots Magazine of Edinburgh*, Vol. 15, p. 88 (1753). A letter sent by Renfrew and attributed to the Scotch scientist Carl Marshal.

Franklin's immediate reply,[5] precisely two centuries ago, may be considered somewhat inexact and unacceptable today; however, in our opinion, it was a broad and penetrating idea, commonplace today, yet still far from being completely mastered by the physicists of the 18th century: to explain this spectacular velocity of electricity along the wire, he postulated that it was not the electric fluid itself which travelled the entire length of the wire at such a high velocity, but rather it was a question of the propagation of motion.

> If the [said] tube be filled with water, and I inject an additional inch of water at one end, I force out an equal quantity at the other, in the very same instant.
>
> And the water forced out at one end of the tube is not the very same water that was forced in at the other end at the same time; it was only in motion at the same time.[6]

The water itself does not travel at a great speed, but the speed of displacement may be great.

Actual measurement of the speed of electricity along a conducting wire was not made until 1834, by Charles Wheatstone.

The other important development in the 18th century was the work of the Jesuit father Joseph Bozolus (1767), a professor of philosophy at the Roman Collegium, who experimented by transmitting an alphabet using only one electric line of two parallel insulated wires; the gap between the wires at one end of the line was used for connecting the plates of the Leyden jar; then a spark burst in the little gap at the other end.

The interesting feature of Bozolus' system was his alphabetical code, made by combining a certain number of successive sparks at irregular time intervals. Morse's code, some seventy years later, was of the same type, but considerably more practical.

One might mention the electrostatic telegraph of the French mechanic L. Lomond (1787). However, the account which we found of it was too abstract to permit a full understanding of its operation. In conclusion it is stated that Monsieur Lomond electrically transmitted messages to Madame Lomond across the house by means of only one conducting wire.

ELECTRICAL COMMUNICATIONS BY WIRE

The new century began with the announcement of Volta's pile and the continuous electric current. In the same year the Spanish physician and physicist Francisco Salva y Campillo, who had previously invented a telegraph run by electricity produced by friction, used galvanic current (from Volta's pile) to transmit signals.

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[5] This correspondence was read at the Royal Society of London, but it was not published in the *Transactions* upon Franklin's request. It appears, instead, in the latter's works. See, for example, "The Works of Benjamin Franklin," by JARED SPARKS, Boston, Hilliard, Gray and Co., 1837, Vol. 5, p. 315.

[6] *Ibid.*, p. 317.

Following this discovery, experiments with telegraphy increased tremendously during the first years of the new century, and, at the first indication of the practicality of the telegraph, a number of patents were issued.

We should like to mention Samuel Morse immediately, but it seems better to talk of Volta first, for he also attempted to use electricity for transmitting at a distance. He introduced electrolytic methods of receiving signals, but the discovery of electromagnetism, twenty years later, by H. C. Oersted [7] (1820), gave rise to a new series of accomplishments.

These accomplishments are associated with names highly esteemed among physicists. Oersted himself began the series, and two other illustrious men we cannot forget here are Gauss and Wheatstone.

Carl Frederick Gauss, the giant of physics and mathematics, together with his colleague W. E. Weber, apparently had no intention of creating a telegraph—he wanted a rapid means of communication between the physics department and the observatory in Göttingen, a distance of 1.5 km (1833). He devised a practical communications system, using one line with two wires and a needle galvanometer to receive the messages. He used a code composed of groups of successive deviations of the needle, both positive and negative.

After a number of attempts, Charles Wheatstone, well-known inventor of the Wheatstone bridge, and William Fothergill Cooke perfected (1840) a telegraph with only one galvanometer needle and only one line, which was constructed and remained in use in England for several decades.[8]

Both Gauss and Wheatstone used positive and negative impulses always of the same length for their codes. In the code used by Gauss and Weber, as many as four such successive impulses were used to represent one letter. When the Morse code was established, only one type of impulse—either always positive or always negative—was used. However, the code with both signs of the current was later re-introduced and was widely used in such applications as W. Thomson's syphon recorder, for example.

In 1837, five years after the famous trip abroad the *Sully*, during which time he developed the idea of his telegraph, Samuel Finley Breese Morse finally obtained a patent for it. But seven more years passed before the first official telegram was transmitted (Washington to Baltimore, May 24, 1844) with his apparatus.

For a century the Morse telegraph has maintained its popularity in the face of more recently developed instruments, mainly because of the basic

[7] Perhaps also announced by the writer and journalist G. B. Romagnosi, a dilettante in "electricism." He probably described it, but in such an obscure and incomprehensible article of August 3, 1802, published at Trent in a periodical entitled *Ristretto dei Foglietti Universali*, that it is quite difficult to understand which phenomenon he was referring to.

[8] The first telegraphic line, under the Wheatstone-Cooke patent, released on June 12, 1837, was put in service (1838) between London and West Drayton (13 miles) for the Great Western Railways Company. The original line had 5 needles and 5 wires; this was reduced to 2 needles and 2 wires, and finally to 1 needle and 1 wire (in the 1840 patent), because the Operators found this type quicker and easier to use.

nature of its operation and the simplicity and strength of its component parts. For example, in Italy there are still 15,000 registered Morse telegraphs, as compared to 3000 teletype systems.

The history of those years from 1832 to 1844 reveals a sordid story of dishonest business interests which developed over patent rights; but it also records innumerable episodes worthy of the purest sentimentalism.

Just to pay homage to Morse, we will mention the malevolent comments on his work which appeared in a recent Italian book on the history of science; but, in the same book, the malignant criticism is largely neutralized by these lines: "from this type of telegraph (of 1837) to that of the present day, which still bears Morse's name . . . the most important innovations were introduced by Morse himself."

We should also like to mention sweet Miss Annie Ellsworth. During the blackest, lean years for Morse, on the evening of March 3, 1843, he was waiting for the law on telegraph appropriation, already approved by Congress, to be signed by President Tyler. On that evening, Congress was closing its session and preceding laws also needed the President's signature. Morse, who was waiting in the Congressional room, finally gave up hope and went home to sleep. The next morning Miss Ellsworth, the daughter of the Commissioner of Patents, brought him the happy news that the bill had been signed.

What did Morse offer her in his gratitude? She was to transmit the first message. And thus it was: Miss Ellsworth on May 24, 1844, selected the message "What hath God wrought." Morse himself, with this verse of the Bible, sent the first official telegraphic message in the United States, seated at his apparatus, installed for the occasion in the Supreme Court room of the Capitol. Alfred Vail, Morse's able collaborator, received it at a distance of 70 km in the Mount Claire railroad station in Baltimore.

Would it have been better to have rewarded Miss Ellsworth with the promise of future shares of stock in the Morse Telegraph Company? We Latins do not think so, and in Morse's action we find a sentiment which renders him a dear fellow to us.

With this apparatus and the Morse code, the telegraph was born, and by the middle of the century it has been established internationally.

Actually the name "telegraph" had been coined by Claude Chappe (1791) to identify his device for optical transmission and the term became popular, particularly in France and Russia. All children that still read Alexander Dumas' stories know that the Count of Montecristo often used the optical telegraph.

There was, however, a great need for a receiver capable of tracing the signs of the code; only in this case could the apparatus deserve the title of telegraph. It is difficult to say who was the first to realize the advantage of a means of recording the incoming signals. Perhaps it was Harrison Gray Dyar (1828), or Edmund Davy (1838), or Alexander Bain (1846), or even Morse himself (1832).

In the equipment used by Morse in 1844, the signals of the Morse code were received on a strip of paper tape in the form of permanent mechanical impressions. It was then a true telegram. An almost incredible number of different systems were suggested before a definitive one prevailed in practice—the one which records in ink.

Augustus Steinheil, however, was the first to use a device giving a permanent record—in the form of dots on a paper ribbon. His practical telegraph, based on the system developed by Gauss and Weber, was already functioning in 1837 between München and Bogenhausen (3 km).

INCREASE IN NUMBER OF SIGNALS

The Morse code used about forty different signals, enough to transmit letters, numbers and punctuation. The next step was to use the normal alphabet—the dream of the anonymous C. M. Wheatstone also had thought of receiving the signals on an alphabetical dial (dial telegraph). At about this same time the printing telegraph was developed. Alfred Vail, Morse's collaborator, mentioned in a book (1845) that the printing telegraph was in existence in 1837.

The alphabetical telegraph, whether or not it printed, necessarily introduced synchronism into electrical communications. There were two types, both of which were outstanding. One was the start-stop type, exemplified, for instance, by Wheatstone's printing telegraph (1840). This type is often attributed erroneously to Ludwig d'Arlincourt (1861). The other was a true synchronism, of which there was a classic example in David E. Hughes' printing telegraph developed in 1855, but applied to international use only since 1868.

The start-stop type was so devised that through the same electric impulse, one sending and one receiving device were disengaged simultaneously (with the exception of the time necessary for the electric transmission). Both devices completed one cycle (usually one revolution of the wheel) within the same time. If there were, for example, 40 signals to be distinguished, the same number of electrical contacts uniformly distributed along the edge of the two wheels could effect a two-way correct correspondence between the transmitted signal and the received one, if synchronism between the two wheels were accurate to about 1 per cent. Synchronism within this limit was delicate but not difficult.

If one considers that in the present teletypewriters there are only five signals, to which are added the disengaging signal and a final signal to reset the machine, the start-stop seems an apt device for a rudimentary but adequate synchronism.

True synchronism may be obtained, and we might even add "easily," as long as the transmitting and receiving instruments are tightly coupled. Paul La Court's phonic wheel (1878) served excellently for a number of decades, and we would not say that the assemblies used today in television are conceptually different, although a great deal more refined.

The start-stop principle and the principle of true synchronism have alternated in popularity in telegraphy. At present, with the preeminence of the Baudot code, the start-stop principle predominates. In the transmission of images, however, particularly in television, true synchronism is used.

P. L. Schilling may be called a pioneer in the Baudot code. In the same year (1833) in which the Gauss and Weber telegraph appeared, Schilling pointed out that by combining two opposite signals, furnished by a direct current either positive or negative, there resulted from five successive impulses a number of distinct signals ($2^5 = 32$) sufficient for telegraphy. But Schilling made the mistake of using five lines for transmission and five needle galvanometers for reception; in this way the five impulses which determined a letter could certainly be simultaneous, instead of being in a series as in Baudot's code; but the advantage derived from the speed of transmission could not compensate for the expense of the multiple line.

Emile Baudot [9] amended this code (1874) by using a series of impulses on one line only, and so the code must be associated with his name. The intrinsic value of the code was the uniform balance in the composition of each signal: five impulses (positive or negative) were necessary and sufficient for each one.

Baudot merits a place of the highest honor in the history of the teletypewriter, by virtue of his *combinateur* or printing translator. It is the device for automatically translating each electric signal of Baudot's code into a printed letter.

Baudot, an engineer in the Post Office and Telegraph Company of France, did not perfect his translator without a great deal of work: the device which evoked a favorable comment from his superiors was the thirty-third! But, when he made his first test between Paris and Bordeaux on November 12, 1877, the apparatus at once proved to be a huge success.

The translator did not solve the entire problem of the teletypewriter, but it was an essential part of it. The teletypewriter uses a standard typewriter keyboard, so arranged that when a key is struck, the five impulses of the corresponding letter, plus the two terminal signals, are sent. At the receiving station it is necessary that the set of arriving impulses activate the translator in order that the transmitted letter can be imprinted upon paper. Every teletype station must have a translator fit for both sending and receiving letters; H. L. Krum and E. Kleinschmidt introduced it during the years of the First World War. Thus, the teletypewriter was born, and as far as it is economically feasible, it has replaced every other type of telegraphic machine.

The next—more ambitious—aim was to transmit telegraphically a manuscript or drawing, or even a picture, perhaps even a picture in color. For

[9] He has given us one of the most outstanding contributions to telegraphy. He still lives in the memory of some of our Italian telegrapher friends, who knew him personally, as a modest and dear old man.

this process, it was necessary to increase greatly the number of distinguishable signals. The original 32 signals in the Baudot code were expanded to about 60 through using double rows of symbols similar to capital and small letters on a typewriter. Even this was by far insufficient to transmit pictures, and a new system had to be developed for sending halftone reproductions and for use in television.

In halftone photo-engravings, the image is formed of a lot of black dots —from 1000 to 5000 per square centimeter according to the degree of refinement required in the reproduction. For satisfactory but less detailed reproductions, such as appear in newspapers, a smaller number of dots per square centimeter is sufficient. In order to transmit a picture electrically, with the same degree of refinement that a photo-engraving has, one needs as many distinguishable signals as there are dots. If a color reproduction is desired, a trichromatic method is used, tripling the number of signals.

Although telegraphic transmission of images does not require the perfection attained in certain methods of photo-engraving, thousands of distinct signals are still needed to define the reproduced image.

For certain types of handwriting transmission (facsimile), a simple apparatus such as Elisha Gray's teleautograph (1893) was—and is—quite sufficient.

But, preceded by initial developments by Bain (1843), Blackwell (1847) and Hipp (1851), Giovanni Caselli's pantelegraph must be mentioned. It was put in service in 1855–56 and tested on the Paris-Amiens line until 1861. It was then placed at the public's disposal, on the Paris-Lyon telegraph line on December 16, 1865, and later, on the Lyon-Marseilles and Paris-LeHavre lines. However, a full quarter of an hour was needed to transmit one image. The transmission proved to be so expensive that the pantelegraph lines were taken out of service after three years.

Nevertheless, two very fundamental concepts were established with this instrument, which can be considered the prototype of modern phototelegraphic and television equipment. In the pantelegraph, correct scanning of the image and adjustable synchronism at the receiving station were attained. Today, although about seven minutes are still needed to transmit a 10 cm $\times$ 12 cm image by phototelegraphy, a television image is registered in about 1/25 of a second. With television, moreover, there is simultaneous sound transmission.

Everyone knows that nowadays living scenes and movies are the daily program of Television. This is the culmination of the efforts of G. R. Carey (1875), who was the first to use selenium in photoconduction, and of Paul Nipkow (1884), who invented the first scanning device—Nipkow's disk.

Finally, telephony was an even more ambitious goal for electrical communications. A famous popular science writer, Guillaume Louis Figuier, in the middle of the 19th century wrote: "Telephony or musical telegraphy has as its purpose the establishment of correspondence between two distant

persons by means of a combination of a few easily recognized sounds." Well, it is a rather uncommon definition, but we can accept it!

It is a pity that there is so much bitterness associated with the invention of the telephone, an invention we do not hesitate to consider the greatest aid to human affairs which man has ever invented.

The reader of these pages will realize that the pioneers in electrical communications often had trying years, and not only due to difficulties encountered in their work—for this would only add to their fame—but there were difficulties caused by business disputes, and from these no one, pioneer or not, emerges greater or purer.

The history of the telephone, like the histories of other significant inventions, reveals a rather sordid story in which the justifiable ambition of the inventor meets with the meanest business deals and national prides.

Innocenzio Manzetti, an obscure mechanic from Aosta, Italy, probably had the original idea for the telephone, or perhaps it was Antonio Meucci, a Florentine artisan who migrated to Havana and then to the United States, or Phillip Reiss, or perhaps still others. Certainly it was Reiss (1860) who first used the name "telephone" to designate the entire apparatus.

The question of who invented a reasonable transmitter is also a very difficult one. Charles Bourseul, an official in the French Post Office and Telegraph Company, proposed (1854) to modulate a current by using a thin plate which, vibrating as a result of sound waves, would open and close the circuit. Phillip Reiss built such a device in 1860. Of course, it did not have the fidelity to reproduce recognizable words; it could repeat a sound so far as it contained one dominant frequency.

In the beginning, in order to have telephonic current modulated by a voice, Manzetti, Meucci (1871),[10] Bell (February 14, 1876) and others who, almost simultaneously with Bell, filed their patent applications for a telephone (Elisha Gray, February 14, 1876, two hours later than Bell; J. W. McDonough, April 10, 1876), all used the reversible telephone. But the energy obtainable in the modulated current was so weak as to be serviceable in a line only several hundred meters long. Still more, this possibility could only exist owing to the extreme sensitivity of the human ear.

Then to whom are we indebted for the telephone? We would say:

(1) To Hughes (1877) belongs the credit for the carbon microphone and for this name. This can supply an audio current with a power greater than that which a simple telephone can produce. The names of the following should be associated with Hughes: Thomas Alva Edison, Emile Berliner and, especially, Henry Hunning, who had first proposed a granular carbon microphone.

[10] Only in 1886, three years before his death, did he see the priority of his patent recognized by the Supreme Court of the United States, but it had expired years before that.

(2) To Edison (1877) goes the credit for the microphone transformer which, by increasing the voltage of the audio current, permits a long distance transmission.
(3) To Alexander Graham Bell goes the honor of founding one of the most grandiose of technical-industrial, and later scientific, organizations in existence.

On October 9, 1876, the first telephone line in the world was put into service, connecting Boston with Cambridge, Massachusetts, a distance of a little over three kilometers. In March of 1877, subscribers were accepted. The first telephone exchange in the world was established several months later at Lowell, 40 km from Boston, with 45 subscribers. On July 9, 1877, the Bell Telephone Company was founded and by the end of that year there were 2600 telephones in use in the United States.

In January, 1878, telephone offices were opened in New Haven and Detroit. By 1900, two million telephones were in use throughout the world. In 1952, approximately eighty million were in existence, of which forty-nine million were in the United States. Washington has more than one telephone for every two inhabitants; in Milan, there is a telephone for every three inhabitants.

A new chapter in the history of the telephone began with the Connolly brothers and MacTighe of Washington (1879). They developed an automatic telephone exchange with eight numbers, and demonstrated it at the Paris Exposition in 1881. In 1886, G. B. Marzi independently designed and constructed the first automatic telephone exchange with ten numbers, which operated for three years in the Vatican Library.

But the automatic telephone really became a practicality with Almond B. Strowger's [11] patent application (1889) for a telephone exchange of a thousand numbers. The patent was granted in 1891, and in 1892 the first automatic telephone exchange was opened to the public, in La Porte, Indiana.

Progress was slow. Even in the 1902 edition of the *Encyclopaedia Britannica,* a telephone exchange with two thousand numbers was cited as the largest, but there were also prudent comments on the possibility of fuller developments. Europe had to wait until 1908 for the opening of its first automatic telephone exchange (Hildesheim, 1200 numbers).

LINES

So far we have discussed only telegraphic devices, but the importance of the line was immediately evident in order that the cost of each type of telegraph might not become prohibitive. Therefore, in the preceding pages we have mentioned only very briefly the telegraphic methods which used more than one line. Furthermore, was a line to contain two wires, or, more economically, one wire, since it uses ground to close the circuit?

[11] We did not imagine that among our pioneers an undertaker would also have a place, but of such a profession was Strowger.

There is quite enough material on the use of only one wire to write a lengthy history of lawsuits and first rights of invention.

Steinheil (1838) found out that he could transmit even if one wire of the two-wire line was broken and on the ground—but others had already pointed that out. Then there was Francisco Salva who, anticipating what might be easily deduced quantitatively by applying Ohm's laws (1827) to an earth plate, pointed out at the end of the 1700's that a galvanic current could use the ground as a return lead—a fact which had been known about electric fire for a century.

Was the use of only one conductor for the transmission of electrical communications a true improvement? Even now it is difficult to answer affirmatively. If there are many telegraph lines in a region with a single conducting wire (the return lead being the ground) some inconvenience can arise and the more costly and more advantageous two-wire lines are preferable.

Once the telegraph had been proved practical, the next goal was to join the most distant parts of the world. But the energy conveyed along the line was quickly exhausted, and in the useable conducting wires (iron, brass, copper) a relay was needed about every ten kilometers to recharge the line without distortion of the signal.

Morse, together with Leonard D. Gale and Joseph Henry, made an elementary relay, but a more complicated problem arose as soon as it became known that a signal was distorted on a long aerial line, and to an even greater extent in an underwater cable and in a grounded one.

The idea of spanning the Atlantic Ocean with a telegraph cable had already been Morse's dream (1842), but what a long story was involved in its realization! Made possible by the use of gutta percha insulation (W. Siemens, 1846), this project was to see its practical fulfillment after two big failures, only at the laying of a third transatlantic cable in 1866.

The following contributed substantially to the success of the transatlantic telegraph cable: William Thomson's use of the syphon recorder (1867); the Morse code in the form known as trivalent, also attributed to Thomson (instead of sending unidirectional dots and dashes, both negative and positive impulses are used, one for the Morse code's dots and the other for the dashes).

The difficulties encountered in underwater telegraphy gave rise to many important theoretical studies, such as Thomson's works, and, much later, those of O. Heaviside (1889). From the works of the latter, the terms *pupinization* (Michel Pupin, 1899) and *Krarup loading* (Karl Emile Krarup, 1902) of the cables claimed their origin. As a result of these studies, the speed of signal transmission was increased and signal distortion was reduced, both within commercially acceptable limits.

Neither of these two methods for improving the properties of lines has lost its importance, even though the advent of electronic amplification has provided considerably more efficient methods for multiplying the effective

transmitting distance and for overcoming signal distortion. Electronic amplification appears even more powerful when one considers the part it plays in long distance telephony, at distances previously considered impossible.

It behooves us, nevertheless, to mention that, before the advent of electronics, the telephone relay (for example, H. E. Shreeve's mechanical amplifier, 1903) had also achieved some promising results in long distance telephony.

The problem of the highest utilization of the line became more urgent as the length of the line increased. Now, for several years past, this subject has been included as a regular chapter in texts on information theory, but, in an empirical form, it had become apparent soon after Morse's initial experiments.

To Bain (1846) goes the credit for the perforated paper strip, prepared at the telegraphic sending station according to a code patterned after the Morse code, and then placed in the transmitting apparatus. Wheatstone's automatic telegraph (1859) is the very machine which, by substituting the perforated paper strip for manual operation, increases appreciably the speed of telegraphic transmission and the utilization of the line. Today it is said that it "increases the flow of signals" on the line.

A simple instrument (the duplex, 1853) was suggested by Julius Wilhelm Ginth to effect simultaneous telegraphy in two directions on the same wire. The same concept was later perfected by use of the artificial line (1854, C. Frischen; 1872, Joseph Barker Stearns).

Only two years after the duplex system, the diplex was suggested (1855) by Stark, whereby two telegrams could be sent in the same direction on the same wire at the same time. Other complex transmission systems followed, such as Edison's quadruplex (1874) and the various multiplexes.

Moses G. Farmer introduced the idea of sharing one telegraph line among several pairs of users, by placing it successively at the disposal of each pair for a very brief time, but sufficient for the transmission of each one's message. To Baudot, however, goes the credit for the first multiplex system (1874).

In connection with the problem of the highest utilization of the line, three other developments are worth mentioning:

Francis von Rysselberghe solved (1887) the inviting problem of telegraphing and telephoning on the same line.

Edmond Laborde pointed out (1860) the possibility of simultaneously sending alternating currents of different frequencies on the same line and picking them up at the other end of the line with separate resonant receivers (the principle in substance was that of the vibration frequency meter).

Paul La Court (1873) used this principle for a multiplex transmission, but Elisha Gray's name is especially remembered among the pioneers (1874) of this harmonic telegraphy, which could transmit up to a dozen messages on one line at the same time.

Whom must we remember at this point as the pioneer in the use of

electromagnetic waves on a wire, modulated to transmit signals, either telegraphic or telephonic, or both, or, even better, a wire carrying at the same time a lot of channels on each of which a communication distinguishable to a distinct receiver could be sent? To this unknown pioneer must be given the credit for the prodigious results of the hundreds of channels used today in a single coaxial cable.

PARENTHESIS

Here we must pause for two reasons:

One, the techniques which science in continuous development has placed at our disposal, are gradually bringing together, in the field of electrical communications, the use of both types of communication—with and without conducting wires.

Two, we want to limit ourselves to the pioneer phase only, but we can no longer overlook relatively recent contributions, especially in the field of electronics. Without this mention of electronics, we have experienced some difficulty in writing our preceding pages.

It is very doubtful that J. J. Thomson, W. Kaufmann and F. Braun could have foreseen the ultimate uses of cathodic rays constituting, according to O. Lodge's picturesque expression, "the fourth state of matter." It is equally doubtful that T. A. Edison, H. Hertz, G. Elster, H. Geitel, or even O. W. Richardson could have foreseen the uses of thermoelectrons and photoelectrons.

We would say that the first practical applications of electronics were J. A. Fleming's high frequency rectifier diode and the triode anounced almost at the same time by Robert von Lieben (Austria, March 4, 1906) and Lee de Forest (U.S.A., October 25, 1906).

But prior to these, Ferdinand Braun comes to mind. At least two devices which are among the most significant in current electrical communications technique claim their origin in this man's studies: the crystal rectifier (1877) and Braun's tube (1897) which, after having been used in the first quantitative experiments on the nature of electrons, has become the progenitor of the cathode ray oscilloscope which can be considered unquestionably the very heart of the countless wonders of modern techniques—from radar and related instruments, to television, to devices which can measure time in millimicroseconds.

Here we meet Lee de Forest, who, protected by all-inclusive patents, was strongly determined to extend his authority upon a lot of inventions, and to go down in history as a leading figure in litigation.

But in texts which seem to be devoid of prejudice or concealed profits (and in the first decades of the century there was a great deal of these), von Lieben is given as the inventor of the telephone thermionic amplifier (1911), and to Alexander Meissner (1913) is attributed the oscillator employing an electrical triode.

Now none of the three would have made much progress without the work of Irving Langmuir (1913) and the contemporary work of H. D. Arnold, who showed the necessity of using very high vacuum tubes to attain the required constancy and fidelity.

And now let us remember at least two more names: the thermoelectronic oscillator would not have reached its present stage of development without W. G. Cady's researches (1922) on the use of quartz (piezoelectric) plates as the best frequency controllers and without G. W. Pierce's (1923) oscillator circuit, stabilized by means of a piezoelectric plate.

WIRELESS

One of us, fearing another visit from Polybius, would have maintained that visual signalling between stations in ancient times was really electromagnetic communication. However, the ancients were content to keep the same system for thousands of years, without making perceptible improvements.

It is necessary to come to Claude Chappe (1791) in order to find a substantially improved optical signalling system, and we have already said how wrong it was to invent the name "telegraph" just in order to baptize it. The system was a network of stations for regular service between distant cities. Between Paris and Lille, for example, a distance of about 200 kilometers, 22 repeater stations were needed. At the time of Napoleon's downfall, the network in France consisted of 1800 km of "telegraph lines" and the number of stations rose to 533 before the advent of the electric telegraph. The system was also used in other countries, notably in Russia.

But Chappe's work was a swan song rather than that of a pioneer, and optical transmission has no place here.

"Wireless communication" has a very different meaning.

History tells us how the philosopher Giambattista Della Porta, known to many for his *Magia Naturalis* (1569), described therein an experiment with magnetic needles, in which, as one needle was turned on an alphabetical dial, the other turned just as much on a similar one, so that both were indicating the same letter. And the story had some credit, even though it was prudently stated that not every magnet can produce such "sympathetic" needles. It seems that Galileo himself considered the possibilities of transmitting signals at a distance "by attraction of needles." A serious word came from a French father Leurechon, who maliciously wrote about such a discovery: "It is wonderful, but I do not believe there is such a magnet; moreover, it is not practical [imagine!] since betrayals would take place too frequently and too mysteriously."

Yet in 1711, in Addison's *Spectator*, the story was repeated, embellished with the moving episode of two friends who communicated with each other across cities, mountains, seas, deserts, and even an entire continent. It later became poetry.

Again: "wireless communication" has another quite precise meaning; there was no hope for a reasonable method of wireless electrical communication until the discovery of magnetic induction (1831, Michael Faraday); but the hope, which was born in Morse himself, was short-lived. Not until J. C. Maxwell's powerful synthesis and H. Hertz' miraculous experiments was it possible to transmit energy by electromagnetic waves and to produce and receive such waves. Well, it seems that neither of these great physicists was concerned with using his waves for the transmission of signals.

It was up to a self-taught, persevering young man from Bologna, endowed with a rare understanding of physics, the twenty-year-old William Marconi, to begin (1894) the research which led him to results worthy of the fame and honor bestowed upon him.

In the beginning things were difficult for him also, even though his difficulties did not last as long as Morse's for example. Marconi also suffered from the skepticism of responsible agencies, the irony of several contemporaries, the disputes over priority and the struggles to establish his transmission system on a practical basis.

Marconi certainly made use of devices which were already known (Augustus Righi's oscillator, O. Lodge's coherer, Popoff's antenna). It must be said, however, that he substantially improved each one.

In our opinion, in the very beginnings of radiotelegraphy when very little was known about the importance of the ground and of the antenna's functions, the greatest credit due to young Marconi is for having realized the overwhelming importance of tuning between transmitting and receiving stations. Marconi probably would have had very poor results from his tests if he had not held steadfastly to this belief and cherished it, as far as possible, from the very beginnings of his experiments, when he succeeded in transmitting wireless signals up to a distance of several hundred meters (1895, Pontevecchio, near Bologna).

Two years later (1897) wireless telegraphy was established across the Bristol Canal (5 km between Lavernock Point and Flatholm). Two years later the English Channel was spanned (50 km) and two years after that, the Atlantic Ocean between Poldhu (England) and S. Giovanni di Terranova—a distance of 4500 km, on December 12, 1901—too.

Distance had been conquered quickly by wireless telegraphy, but by very primitive means. A long road still lay ahead, but it was travelled in a few decades!

Electromagnetic waves from a spark generator were notably weak, and no means was known at the end of the century for obtaining the continuous electromagnetic waves needed for radio telephoning. With W. du Bois Duddel (1900), who recognized the negative resistance characteristic of the arc and hence the possibility of obtaining from it a persistent oscillation with fixed frequency, hopes of generating continuous oscillations of high frequency (on the order of 10^6 cps) took shape, and a little later (1903) they were realized by Valdemar Poulsen.

This did not stop F. W. Alexanderson, spurred on by R. A. Fessenden, from constructing a high frequency alternator (still only 0.5×10^5 cps) with an iron rotor (1906). It did not prevent R. Goldschmidt (1907) from making his medium frequency alternator to be used in connection with a frequency multiplier. Thus in a very well known treatise, much later (1926), the generators of high power continuous waves are mentioned in order of importance—and the order is exactly Poulsen, Alexanderson, Goldschmidt. Oscillatory circuits using thermoelectronic tubes are still neglected.

With the realization of continuous waves, Fessenden's ardently desired dream of radiotelephony by means of modulation of carrier waves finally came true. Radiotelegraphic communication was established on December 11, 1906, between Brant Rock and Plymouth, Massachusetts (18 km). A few days later Telefunken sets were attaining 40 km (December 20, 1906).

Two years before this (*Rend. Acc. Lincei*, Vol. 13, p. 86, 1904), Quirino Maiorana's [12] account of his experiments with the wireless telephone appeared. He communicated telephonically between two distant points of the Istituto Superiore delle Poste e Telegrafi (Rome) through numerous intervening walls of the building. A little while later he repeated his experiments between the same institute and Monte Mario (Rome), a distance of 4 km.

After an interval of fifty years, it is easy to judge how "out of line" Maiorana's complex apparatus was. After improving his equipment, and by using Poulsen's arc (instead of the previous high frequency spark), he achieved radiotelephonic communication (1907) between Rome and Messina, a distance of 500 km; but at the same time Fessenden had just spanned the 500 miles separating Brant Rock from Washington.

These are the same years which mark the birth of the thermionic tube, but a number of years went by between its first applications in radio receiving and the time when its paramount importance was asserted in the generation and amplification of high frequency oscillations. One must bear in mind that in 1914, yet, Marconi described and patented a multiple spark transmitter to obtain "nearly" continuous oscillations.

A little later (1915), a small electronic generator, producing a very weak antenna current, was experimented upon in Italy.

RADIO TRANSMISSION

For many years several fundamentals of radio transmission were unknown. Gradually the use of long waves in long distance transmission gave way to short waves. Marconi's name is still (1916) associated with re-

[12] Personal reasons justify this affectionate mention of a ninety-year old man who is still engaged in research in physics. Eligio Perucca had the honor to succeed (1922) Quirino Maiorana in the professorship of Experimental Physics at the Politecnico di Torino. Professor Quirino Maiorana was the Director of the Istituto Superiore delle Poste e Telegrafi di Roma from 1908 to 1914; Vittorio Gori is now its Director.

search on short waves and their practical acceptance. We should mention as pioneers the large number of amateur radio operators during the 1920's.

To short waves ($\lambda = 20 \div 100$m) falls the honor of having for the first time circled the world, a trip requiring a little less than $\frac{1}{8}$ second. It was only in 1924 that the first radio communication between aircraft and ground stations was finally established by short waves, and this contact, made so tardily one might say, was spectacularly successful: from a ½-watt transmitter in the aircraft, communication was established with ground stations at a distance of approximately 3000 km.

Later on, research entered the field of ultra-high frequency waves ($\lambda = 2 \div 10$m).

Before the introduction of these ultra short waves, there was some attempt to find the direction of the received wave. The radiogoniometer of E. Bellini and A. Tosi (1907) is the only apparatus to be remembered here.

Afterwards, through use of the ultra-high frequency waves, wireless came to the straight line radio communication, which owes its development to ever-shorter wavelengths, down to decimeter values. Here the parabolic reflector gives a gain of 10^3 both in transmission and reception; here the power of a 1-watt transmitting set is as effective in the favorable direction as a 1-kw transmitter.[13]

ELECTRICAL COMMUNICATIONS IN A BROADER SENSE

In the preceding pages we have limited ourselves to the more outstanding phases of electrical communications in a strict sense: the exchange of signals from a transmitting station to a receiving station, both of which are prepared for the exchange. Several cases of electrical communications in a broader sense, then, have not been mentioned as yet. We turn to these briefly.

Alexander Popoff was the first to pick up electromagnetic waves from a distant thunderstorm. During recent years Harald Norinder, in Uppsala, has been methodically studying the electromagnetic waves generated by these discharges and from them he plots storm charts—a field of research which is very promising in atmospheric physics.

We believe everyone has heard of the wonders of radar and analogous systems during the war, and even more in peace. We deeply regret that

[13] Perhaps Perucca was dreaming again, when at this point the Greek historian reappeared.

"You were about to quote me again, but I thought it over. Down there," he said, "they have found out about my visit to you, and I was reproved because of it. I have resigned as President of the syndicate. I deserve it, however; I realize that there is nothing which relates my torches to radio communication."

"We agree, Mr. Polybius. I should like to beg you to pay, on our behalf, our homages to Ben Franklin."

As Polybius was just leaving, he turned with a contrite air:

"I cannot; he is in another section, on another level. He is among the benefactors of humanity."

we don't know the names of the pioneers to whom we owe such a useful invention.

Nor should a word pointing out researches and results in regard to telluric currents be considered foreign to our theme in general.

Finally, referring to radio astronomy which has become so popular recently, we believe that the scientists engaged in this field are all pioneers in "active service"—it will be necessary to wait a few years before discussing this item.

We have the impression that he who shall look at the pioneers in communication in a few decades, will find the time to be already ripe to say a few words on pioneers in the science of information theory. We have not discussed it. We have remained silent about too many things within these few pages.

CONCLUSION

We have finished. But while putting down the pen and taking a glance at the past two centuries which we have tried to evoke here, the words of Benjamin Franklin [14] come to mind:

> There are everywhere a number of people, who, being totally destitute of any inventive faculty themselves, do not readily conceive that others may possess it; they think of inventions as of miracles; there might be such formerly, but they are ceased. With these, every one who offers a new invention is deemed a pretender; he had it from some other country, or from some book; a man of their own acquaintance, one who has no more sense than themselves, could not possibly, in their opinion, have been the inventor of any thing. They are confirmed, too, in these sentiments, by frequent instances of pretensions to invention, which vanity is daily producing. That vanity, too, though an incitement to invention, is, at the same time, the pest of inventors. Jealousy and envy deny the merit or the novelty of your invention; but vanity, when the novelty and merit are established, claims it for its own.
>
> The smaller your invention is, the more mortification you receive in having the credit of it disputed with you by a rival, whom the jealousy and envy of others are ready to support against you, at least so far as to make the point doubtful. It is not in itself of importance enough for a dispute; no one would think your proofs and reasons worth their attention; and yet, if you do not dispute the point, and demonstrate your right, you not only lose the credit of being in that instance ingenious, but you suffer the disgrace of not being ingenuous; not only of being a plagiary, but of being plagiary for trifles. Had the invention been greater, it would have disgraced you less; for men have not so contemptible an idea of him that robs for gold on the highway, as of him that can pick pockets for half-pence and farthings. Thus, through envy, jealousy, and the vanity of competitors for fame, the origin of many of the most extraordinary inventions, though produced within but a few centuries past, is involved in doubt and uncertainty. We scarce know to whom we are indebted for the compass, and for spectacles, nor have even paper and printing, that record every thing else, been able to preserve with certainty the name and reputation of their inventors. One would not, therefore, of all faculties or quantities of the mind, wish, for a friend or a child, that he should have that of invention. For his attempts to benefit mankind in that way, however well imagined, if they do not succeed, expose him though very unjustly, to general ridicule and contempt; and, if they do succeed, to envy, robbery, and abuse.

[14] JARED SPARKS, op. cit., Vol. 5, p. 354.

Perhaps Franklin, while writing these golden words, thought of the skepticism with which his theory on the electrical nature of lightning was received. We are also thinking of the sneering words to which the painter Morse must have listened as he waited, without hope, as Congress discussed whether the American Government should stand the expense for a test of his telegraph. We are also thinking of that insignificant Italian magazine which repeatedly jeered at Marconi, inviting him to send a wireless message at least across the straits of Messina (4 km), if he could.

At the beginning of this century, an Italian comedy became famous; its title was *Miseria e Nobiltà*. Why do these two words come to our mind at this time?

Nobiltà. One cannot think, without emotion, of the significance to humanity of the development of a method of wireless communication capable of travelling 300,000 km a second. Or, think of the importance of that "SOS" which comforts, helps and often saves people in danger at sea, in deserts, on polar icefields, or abandoned to their fate, in a lonely, inadequate hospital. We are reopening a volume in which a few of the above topics are treated, and in it we find an account of the Service for Radio Medical Assistance of the International Radio Medical Center for those travelling at sea. It is a service entrusted to Italy. We are proud of it, first as men, then (please forgive us) as Italians.

Miseria. It is the moral poverty frequently accompanying material wealth, which fed the most vicious business struggles, that developed over patents for electrical communications. Even in the selection of the distress signal "SOS," arrogance and prestige occasioned violent disagreements!

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". . . Governor Thomas was so pleas'd with the construction of this stove . . . that he offered to give me a patent for the sole vending of them for a term of years; but I declin'd it from a principle which has ever weighed with me on such occasions, viz., *That, as we enjoy great advantages from the inventions of others, we should be glad of an opportunity to serve others by any invention of ours; and this we should do freely and generously.*"

Autobiography

HOW MEDICINE BECAME A SCIENCE

BY

SIR ZACHARY COPE[1]

The Medical Society of London

It is appropriate that the Medical Society of London should take part in the celebration of the 250th anniversary of the birth of Benjamin Franklin, for he was one of its most distinguished early Fellows. The Society was founded in 1773 and in 1787 Franklin was elected a Fellow. At that time Franklin was well-known both as a natural philosopher and as a statesman, and the Society felt it an honour that he should consent to join, while we have reason to believe that Franklin esteemed it a privilege to be accorded the Fellowship of the Society. He was a friend of Lettsom and of Fothergill and their connection with the Society would undoubtedly have carried great weight both in inducing him to become a Fellow, and in obtaining for him a favourable reception from the other Fellows of the Society.

In commemorating this great man it is pertinent to consider the state of medicine at that time and to estimate how far scientific method had invaded the medical art. Medicine has always been an art, debased though it sometimes was, but only recently has it approached to the standing of a science. It is unlikely that it will ever become an exact science, although in some limited fields the finding of specific remedies for readily diagnosable conditions has made a nearer approach to exactness than was at one time deemed possible.

What do we mean by science? The reply sometimes given—measurement—is not sufficient. Measurement is an important element in most scientific procedures but it is not the whole of the scientific method. Science is that body of knowledge which has been acquired by a three-fold process, one or other element of which may at different times predominate. First, there is accurate observation; secondly, comes a process of thought, either induction or deduction, leading to certain views on the subject; the third element is experiment devised to throw light on the subject with the view of confirming or rejecting any particular idea chosen for consideration. Bacon, in his *Novum Organum* and the *New Atlantis*, was one of the first to teach the need for experiment, and to lay down rules for scientific work. Science grows by the fertilization of facts by ideas, while experiment is the touchstone whereby truth is elicited. Scientific genius shows itself in the formulation of fertile ideas and methods, and in the choice of suitable experiments.

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At no time before the Renaissance were conditions favourable for the development of scientific medicine. In ancient Egypt and in Greece there had been considerable observation of anatomy, and Galen certainly tried experimental methods, but basic physiological ideas were fanciful and unsupported by accurate observation. It is astounding that the views of Galen should have held the field for so long, and have cast such a paralysing blight upon medicine for a thousand years that no one dared to question anything which he had asserted.

An exception must be made for botany which from very early times has proved of practical interest. From the time of Theophrastus, and later Dioscorides, right through the Middle Ages, plant-lore has been studied and the medicinal value of many herbs attested. Large and elaborately illustrated Herbals were printed soon after the advent of printing, and in such books the seller of herbs and even the layman could learn and, if he wished, practise treatment according to the views then current.

The year 1543 can be taken as a landmark giving some indication that a change of outlook was approaching; in that year were published two books of great significance. The one was the *De Revolutionibus* of Copernicus, in which the long-held view that the earth was the centre of the universe was quietly and logically shown to be wrong. The other book was the *De Fabrica Corporis Humani* of Vesalius, the first book on human anatomy written and accurately illustrated from actual human dissections. In this remarkable book Vesalius proved that Galen was fallible. He thereby opened the flood-gates of free and impartial observation. The art of printing, which was then a comparatively recent discovery, greatly helped to disseminate the new knowledge. Vesalius taught men to see for themselves, but there was to be a long and arduous period before the basic sciences of medicine developed.

Scientific medicine has been gradually built up on the basis of those sciences which deservedly form a large part of the present medical curriculum. Knowledge of biology, physics, chemistry and physiology has gradually grown over a period of centuries, and the growing knowledge has been assimilated into medicine by instalments. The transition has been gradual and much erroneous teaching due to imperfect knowledge has at times been current. We can but comment on the most important developments in the main stream of medical advance.

The year 1600 was noteworthy for the publication of an important work by a scientifically minded doctor—the *De Magnete* by William Gilbert. In this book lies the foundation of what has since proved to be one of the main branches of physical science, electricity, to which, as we shall find, Benjamin Franklin made a noteworthy contribution.

At the very time that Gilbert published his great book, in which he insisted on the need for experimental evidence, another physician, William Harvey, then twenty-two years of age, was studying at Padua and pursuing

the experimental method recommended by Bacon and Gilbert. His master Fabricius (1)[2] had observed and written about the valves in the veins. Harvey formed a view as to their function and devised experiments to test it. His momentous conclusion that there was a circulation of the blood was first announced in 1616 but, perhaps knowing that this view would meet with strenuous opposition, he did not publish it to the world till 1628 when the famous *De Motu Cordis* was issued. The year 1628 marks one of the great dates in the history of medicine for it indicates the birth of rational physiology. Harvey's discovery compelled an entirely new orientation in medicine and set a magnificent example of the correct method to be adopted in attempting further advances. More than anyone else, Harvey introduced the scientific spirit into medicine, and his influence was widely felt. It can hardly be an accident that, immediately after the time of Harvey there should have been so many medical men interested in science that they formed 22 out of the original 115 fellows of the Royal Society, which was formally started in 1660. The names of William Petty, George Ent, Jonathan Goddard, Francis Glisson and Charles Scarburgh show that medical men were taking a keen interest in advancing science. It is unlikely to be due to chance also that Robert Boyle, the great natural philosopher, took such a keen interest in medicine. We know that he exchanged ideas with Thomas Sydenham and accompanied that great observer on some of his professional rounds. Sydenham did not learn his medicine by the traditional academic method current at that time, but he gained his knowledge by accurate observation at the bedside.

The growing interest in chemistry at that time led some to have exaggerated hopes of the efficacy of some of the newly discovered chemical compounds. On utterly insufficient foundation some physicians started a "Society of Chymical Physitians" (2) which claimed that in the new chemicals would be found an infallible remedy for many disorders including the plague. When put to the test their remedies proved of little use and the plague claimed some of their leaders as victims. Three hundred years were to pass before chemistry reached that position in medicine which they claimed for it.

The latter part of the seventeenth century was dominated by the intelligence of Newton whose influence on medicine was indirect. The influence of Newton was still strong at Cambridge when Stephen Hales arrived there, and it is likely that the same influence may have been at work to induce Francis Hauksbee (3) to support Cheselden's lectures on anatomy by teaching his students the mechanics of the human body. The latter part of the seventeenth century saw a large field opened for observation by the development of the microscope. Working with simple apparatus Hooke, Malpighi and Leeuwenhoek gave accurate descriptions of many minute objects. Leeuwenhoek pictured some micro-organisms which have in modern times been identified as common bacteria of the mouth. In the

[2] The boldface numbers in parentheses refer to the references appended to this paper.

same period Robert Boyle's chemical researches showed that air was necessary for animal life, and a few years later Lower and Mayow showed that it was a special part of the air which was essential for respiration; unfortunately the definite discovery of oxygen was not to be made for another century.

Scientific progress may be arrested by the failure of any part of the scientific method. Theories based upon an insecure foundation and unsupported by convincing experiments tend to lead woefully astray. The promising manifestations of the scientific spirit which was so evident in the latter part of the seventeenth century rather faded away in the early years of the eighteenth century which Garrison aptly termed "the age of theories and system-makers" (4). Friedrich Hoffman (1660–1742) and John Brown (1735–1788) taught systems of medicine which interpreted every manifestation of disease in the light of their pre-conceived theories. The clock of chemical research was seriously put back by Georg Ernest Stahl (1660–1734) who, believing that the soul controlled the body, had no use for anatomy or chemistry. By propounding his theory of phlogiston he retarded chemical progress for a generation.

Scientific advances relative to medicine were however made in the early part of the eighteenth century by Stephen Hales (5) that remarkable clergyman whose experimental work was outstanding. Two of Hales' friends, William Stukely and John Addenbrooke, were medical men, and no doubt they influenced the direction of his remarkable powers. In his work on *Haemodynamics* Hales gave the first account of the experimental measurement of the blood-pressure. His work on plant-physiology, and on the ventilation of buildings was evidence of his wide interest in sciences akin to medicine.

It was in the middle of this century that Franklin took a hand in advancing the science of electricity. The properties of the Leyden jar had been described in 1746 and a report of it soon reached America. A certain Dr. Spence introduced Franklin to the phenomena of static electricity and interested him in the subject. Franklin then began a series of experiments in which he showed imagination and enterprise. Working entirely on his own initiative and without previous experience of scientific work, he showed qualities of a high intelligence. The letters in which he described the results of his researches were sent to Peter Collinson, a Quaker friend in London, and by him they were communicated to the Royal Society. Though at first the Royal Society paid little attention to them it was not long before Franklin's reputation in France compelled the Society to take more notice and soon they elected him a Fellow of the Society. Many of Franklin's remarks on electricity have a modern ring because he was the originator of the terms "positive" and "negative," and "plus" and "minus" as applied to electricity. He, more than anyone else at that time and for some time to come, appreciated the possibilities of the new power. In a letter which he wrote in 1751 occur the words,

> I forget whether I wrote to you, that I have melted brass pins and steel needles, inverted the poles of the magnetic needle, given a magnetism and polarity to needles that had none, and fired dry gunpowder by the electric spark. . . . There are no bounds (but what expense and labor give) to the force man may raise and use in the electrical way (6).

It is clear that Franklin would have accepted the modern extensive use of electricity in medicine and in general without much surprise.

In the latter part of the eighteenth century real scientific progress bearing on medicine was made in several directions, in chemistry, in physics and in pathology. Scheele, Black and Priestley contributed to the foundation of modern chemistry but it was Lavoisier who first looked on chemistry with the modern eye. He it was who first dissolved the mists of vague speculation and saw the true meaning of chemical reaction. His *Réflexions sur le Phlogistique* (1783) and particularly his *Traité Elementaire de Chimie* (1789) mark the birth of modern chemistry. Lavoisier based his views upon the secure foundation of experiment and observation, and he had a firm opinion that his views would be ultimately adopted. His words are noteworthy (7):

> I do not expect that my ideas will be adopted at once; the human mind inclines to one way of thinking and those who have looked at nature from a certain point of view during a part of their lives adopt new ideas only with difficulty; it is for time, therefore, to confirm or reject the opinions that I have advanced.

Well spoken and well justified.

The latter part of the eighteenth century is noteworthy for the increase in knowledge of morbid anatomy and surgical pathology. In 1761 the publication of Morgagni's *De Sedibus Morborum,* a monument of observation in which he correlated the post-mortem findings with the symptoms which had been observed before death, marked an epoch in our knowledge of disease. About the same time John Hunter began that period of intense feverish activity in which he collected, dissected, observed and compared, and finally deduced opinions on which he based his teaching and from which present-day surgical pathology is ultimately derived. His example stimulated others. It was without doubt the influence of John Hunter which inspired Edward Jenner and helped him towards the discovery of the value of vaccination against smallpox, and we should also note that Jenner's work was an inspiration to Pasteur fifty years later. It was the first example of experimentally acquired immunity.

In the early part of the nineteenth century clinical science celebrated several successes. Methods of examination had improved by the introduction of percussion, introduced by Auenbrugger in 1761, and of auscultation devised by Laennec in 1816. In addition the knowledge of morbid anatomy in England had been advanced by the publication of Matthew Baillie's *Atlas.* Medical teaching in London was at that time specially concentrated at Guy's Hospital and it was there that the increased knowledge bore most fruit. The names of Bright, Addison and Hodgkin are sufficient to prove that

accurate observation, both of the living and the dead, careful consideration of what one has observed, and confirmation by further observation of nature's experiments on the human frame, may serve to produce real scientific advances. Clinical science conducted with minimal laboratory aid still retains its value. Fifty years ago the valuable researches of James Mackenzie, and still more recently the advances in the field of epidemiology made by Dr. W. N. Pickles, serve to emphasize this point.

Discoveries of the greatest value to medicine were made in the first half of the nineteenth century. In France Berthollet and Berzelius and in England Humphrey Davy followed in the chemical footsteps of Lavoisier, discovered new elements and laid a firm foundation for modern inorganic chemistry. Davy was ahead of his time in putting forward the view that electrical and chemical phenomena might be different manifestations of the same power. The advance of chemistry and its use in medicine was of such importance that when, in 1815, a medical curriculum had to be laid down consequent on the passing of the Apothecaries Act, a course of lectures on chemistry was made compulsory. An epoch-making experiment was made in 1828 when Wöhler heated ammonium cyanate and found that urea had been formed. This synthesis of urea was the beginning of the applications of synthetic chemistry to the organic compounds of the body. More directly connected with surgery was the discovery by Davy of the anaesthetic properties of nitrous oxide early in the century. Davy frequently inhaled gallons of the gas and described his relief from pain when suffering from inflammation of the gums; he needed only to have gone a little further to have been the originator of anaesthesia. It was in the fifth decade of the century that anaesthesia suddenly became practicable. Sulphuric ether had been known for centuries but it was not till 1846 that its anaesthetic properties were so clearly demonstrated at the Massachusetts General Hospital that it sprang into use almost at once all over the civilised world. This discovery stimulated others to try the properties of other substances and everyone knows the dramatic experience of Simpson and his friends which led to the discovery of the anaesthetic effects of chloroform which, incidentally had only been isolated sixteen years previously. Chemistry was proving its worth to medicine.

It was in the second quarter of the nineteenth century that Faraday made his discoveries in electricity which have transformed the modern world and which have been of incalculable benefit to medicine.

The infiltration of medicine by science had so far been slow, but from the middle of the nineteenth century the progress became rather geometrical than arithmetical in rate of advance. Up till 1830 the value of microscopy had been lessened by the difficulty in overcoming chromatic aberration, but in that year Joseph Jackson Lister, the father of the famous Lord Lister, devised a method of remedying that defect. From that time onwards the scope of microscopic observation rapidly extended and the new science of histology was born. In 1837 Schleiden and Schwann demonstrated the

cellular structure of both plants and animals and round about 1850 the microscope became the constant companion of the physiologist and pathologist. The most remarkable result following from the advance of microscopy was the demonstration of the micro-organisms of disease. Though Bassi in 1835 had found that a fungus was the cause of a disease of silk-worms, and Davaine and others had seen the bacillus of anthrax, it was due to the immeasurable genius of Pasteur that, from 1850 onwards, bacteriology became an established science, and acquired immunity was shown to be a practical possibility.

If I were asked to give a definite date for the birth of modern scientific medicine I should unhesitatingly choose the year 1858. In that year Virchow published his *Cellular Pathology* which is regarded as the beginning of modern pathology; in the same year a new world in organic chemistry was opened by the work of Couper and Kekulé who proved the quadrivalency of the carbon atom with the possibility of chain formation in the molecule. In 1858 Pasteur published his paper on the fermentation of lactic acid which has been acclaimed as the beginning of modern bacteriology; while at that time Claude Bernard was at the height of his career as experimental physiologist; he had just demonstrated the glycogenic function of the liver, in that year he showed the vaso-constrictor effect of stimulation of the sympathetic, and he was soon to publish his *Introduction to the Study of Experimental Medicine*, a medical classic. In 1858 Darwin had just completed his *Origin of Species* which was published in the following year. From the British point of view the year 1858 is of importance because it was in that year that the General Medical Council was set up and the Medical Register started. There is clearly some justification for marking that date as important in the history of scientific medicine.

Just before the time that bacteriology became a science there had been a great advance in sanitary knowledge and science. Southwood Smith and Kaye were two observant doctors who showed the need for sanitary reform, and they were supported by that energetic but rather tactless person Edwin Chadwick, who was the moving spirit who got things done. The reforms were based upon conclusions which had been reached by following a logical or scientific method. Southwood Smith collected facts which proved that the death rate was uniformly higher in the filthy, crowded and insanitary slums than in the more airy and less crowded dwellings. It was shown that improvements in the sanitary condition were invariably followed by lessening of the death-rate and diminution of the incidence of disease. This was scientific proof in spite of the fact that the actual cause of the diseases was not at that time known. At the same time Snow showed that impure water could convey cholera. A Royal Commission was appointed, a vast volume of facts accumulated and as a consequence regulations were made and improvements carried out. This was a definite advance in scientific preventive medicine.

Nevertheless medicine could not be called scientific until some of the

main causes of disease were known and until specific remedies could be furnished for some at least of these diseases. Koch (1843–1910), following up the work of Pasteur, laid down the criteria upon which one could depend in judging whether any particular organism was the cause of any particular disease. Using the method of Koch, the proximate causes of many infective diseases were discovered and the possibility of accurate or specific treatment foreshadowed. Pasteur himself discovered a method of producing immunity against rabies, although no organism to which that disease might be attributed had been discovered. Other attempts to produce immunity were for some time not successful.

The effect of Pasteur's work on surgery was immense, thanks to the patient and thorough work of Joseph (later Lord) Lister, whose publication in 1867 of a method of preventing suppuration in wounds by the use of antiseptics opened a new world to surgeons. The mystery of suppuration, of hospital gangrene and of pyaemia was solved and the way to their prevention outlined. Armed with antiseptics or protected by asepsis, and assisted by anaesthesia, surgeons began to be bolder and the vast field of abdominal surgery was explored. For some years, however, much surgery was crude and suffered from a lack of a correct knowledge of the physiology of the body.

The work of Pasteur and Lister, which revolutionised our ideas of medicine and surgery, brings us to modern times. The last sixty years have seen an entire change of outlook upon medicine, and to a lesser degree upon surgery. The rapid development of organic chemistry in the latter part of the nineteenth century enabled chemists to analyse and synthesise compounds, to detect that part of a compound which had active properties, and to form new compounds containing the active principle. In this way they formed thousands of compounds of which a few were therapeutically active. Ehrlich (1854–1915) was one of the earliest exponents of this method, and one of the most remarkable and efficacious of his discoveries was salvarsan or 606. Since that time similar methods have been pursued in many chemical laboratories, often financed by the great chemical manufacturing companies, and many specific remedies have thus been discovered.

On the other hand the work of Pasteur stimulated bacteriologists, particularly Sir Almroth Wright, to extend the work of therapeutic immunisation, both preventive and curative, with very fruitful results. It was also just before the turn of the century that physics began that series of gifts to medicine which greatly enriched it. Röntgen discovered the X-rays in 1895 and in 1898 Madame Curie isolated radium.

The plant of scientific medicine had been growing steadily for three centuries. Science had been gradually assimilated into the texture of medicine but as yet there was little evidence of the flowering of the plant. When the twentieth century opened, medicine possessed few curative remedies and hardly any drug which might be called a specific. Mercury slowly cured syphilis, quinine subdued malaria but neither was a rapid or

certain cure. Diagnosis was still dependent upon the ordinary time-honoured physical examination. The examination of the urine and of the blood was elementary and the laboratory was in most hospitals a small room inconveniently placed. The X-ray department was a small and insignificant dark hole somewhere in the basement; it was more of a curiosity than a serviceable assistant. Gradually at first and recently more rapidly all this has been changed. Those who have been privileged to live through the first half of this century have seen the flower of scientific medicine open widely before their eyes, and they have been able to realise the significance of the manifold scientific accretions of medicine during the past three centuries.

So far as the records of the human race go back there has been nothing like the recent advance in our knowledge of the causation, and our success in the cure, of many of the most serious diseases which affect the human race. It would take many lectures or many volumes to recount the innumerable discoveries. Perhaps the best way to give an idea of the rapid progress is to enumerate a few of the main landmarks. Some of these indicate discoveries, others serve to show the acknowledgment by the laity of the need for scientific research in medicine.

1895 —Röntgen discovered the X-rays.
1896 —Widal devised the typhoid-agglutination test.
Wright introduced anti-typhoid inoculation.
1897 —Ross demonstrated the transmission of the malarial parasite from mosquito to man.
1900–1—Landsteiner identified the blood-groups.
1901 —The Rockefeller Foundation for Medical Research.
1905 —Schaudinn discovered the spirochaete of syphilis.
1907 —The Wassermann reaction discovered.
1909 —Ehrlich introduced salvarsan (606).
1912 —Gowland Hopkins discovered accessory food-factors (vitamins) and founded the study of avitaminosis.
1913 —Schick test for diphtheria introduced.
1922 —Banting isolated insulin.
1924 —Minot and Murphy showed curative effect of liver on pernicious anaemia.
1929 —Alexander Fleming discovered penicillin.
1930 —Wellcome Research Institution opened.
1935 —Domagk introduced prontosil which was followed by many drugs of the same group.
1943 —Florey and Chain purified penicillin.
Nuffield Foundation endowed.

Great advances were made during the War of 1939–45. Dysentery was subdued by sulphasuxidine and other drugs of the sulpha group; malaria was controlled by mepacrin and typhus fever was banished by destruction of the louse-vector by means of the insecticide D.D.T. (dichlor-

diphenyl-trichlorethane). During that war also blood-transfusion was perfected, and thoracic, plastic and cerebral surgery were greatly advanced. During the last fifteen years two further advances of great significance have occurred—methods of anaesthesia have greatly developed and improved, and remarkable achievements in the surgery of the heart and arteries have occurred.

These are but a few of the remarkable series of vital discoveries which have truly transformed medicine and surgery.

Medicine is now a science, based upon a series of exact sciences and itself conducted in a scientific way. Each patient provides a scientific problem which is approached in a methodical manner. The physician or surgeon observes, formulates a diagnosis and confirms or refutes his diagnosis by the experiment of treatment.

Observation has been extended and intensified to a point which would have seemed miraculous fifty years ago. By means of suitable tubes and well-placed electric lights the investigator can have direct vision of the oesophagus and stomach, the rectum and sigmoid colon, the bronchi and the urinary bladder. By utilizing the Röntgen rays he can determine accurately the shape, size and condition of the whole skeleton, or observe any abnormality in the structure or function of any part of the alimentary tract; by similar means he can determine any abnormality in the lungs, and by using opaque fluid he can localize the lesion. The cardiac cycle can be accurately tested, arterial irregularities can readily be determined and the exact position of any aneurysm seen. Even the outline and shape of the cerebral ventricles can be demonstrated. There is no part of human anatomy which cannot in some way be observed by means of X-rays. Observation goes still further. By the use of the microscope and by chemical, biochemical and biological tests one can submit the blood, the secretions and excretions, and even the bodily tissues themselves to searching investigations which supply observations of the utmost value. The number and variety of ways of investigation are now so manifold that the art of the physician, or the lack of it, is shown in the choice of which line of investigation should be called upon in any particular case.

Having made his observations, the physician considers them and forms a tentative diagnosis. As in the more exact sciences the view first accepted is not always the correct one, though in a great many instances it is approximately correct. The true confirmation and testing of the diagnosis lies in treatment. Here even during the lifetime of the younger among us an astonishing advance has been made. Even thirty years ago therapeutics was powerless in dealing with many, if not most, serious diseases. Now there are many infections for which we have a choice of curative remedies, many deficiency diseases for which we can readily supply the missing substance, and many derangements of function which can promptly be remedied. Quite as important developments have occurred on the preventive side of medicine. The remarkable success of immunisation against

diphtheria and the valuable protection afforded by inoculation against a variety of other diseases serve to show how the body can be helped to protect itself. Moreover, many measures have been successfully introduced which prevent disease by providing conditions under which the organism or the carrier of the organism cannot survive; these have served to convert into habitable regions parts of the world which were formerly death-traps. Surgery has become more physiological in its outlook and the older mechanical views have receded into the background. Science has displaced empiricism, observation has taken the place of theory, and experiment is recognised as a logical method of investigation.

Those who have studied the life of Benjamin Franklin will agree that he would have been the first to acclaim the scientific method. I think it likely that, if he had been born in this generation, he would have chosen to be a physician, or possibly a surgeon.

REFERENCES

(1) Fabricius, Hieronymous. "De venarum osteolis," translated by K. J. Franklin (1933).
(2) "The Society of Chymical Physitians" by Sir Henry Thomas, in Science, Medicine and History, essays on the evolution of scientific thought and medical practice written in honour of Charles Singer. Edited by E. Ashworth Underwood. Volume 2, p. 56.
(3) Francis Hauksbee, see "William Cheselden" by Zachary Cope, p. 5. (E. and S. Livingstone, 1953.)
(4) Fielding H. Garrison's "History of Medicine." Second edition. 1917, p. 304.
(5) "Stephen Hales," by A. E. Clark-Kennedy. Cambridge University Press. 1929.
(6) "Works of Benjamin Franklin," with notes and a life of the author by Jared Sparks. Vol. V, p. 258. Chicago. 1882.
(7) "Antoine Lavoisier," by Douglas McKie, p. 232. Victor Gollancz. 1935.

". . . You mention, that you *feel yourself hurt.* Permit me to offer you a Maxim, which has thro' Life been of Use to me & may be so to you in preventing such imaginary Hurts. It is, always to *suppose* one's Friends *may be right* till one *finds* them wrong; rather than to *suppose them wrong* till one *finds* them right. You have heard and imagin'd all that can be said or suppos'd on one side of the Question, but not on the other. . . ."

Letter to Ralph Izard
Passy, January 29, 1778

FRANKLIN'S HOSPITAL, OUR HOSPITAL, AND THE HOSPITAL OF THE FUTURE

BY

SYDNEY P. CLARK[1]

Pennsylvania Hospital

Mid-point, 18th Century, found the North American continent poorly equipped, hospital-wise. Mexico City had, from 1524, the Hospital de Jesús, established by Hernando Cortez; Quebec, the Hotel Dieu, opened 1639 by the Hospitalieres of the Order of Saint Augustine; but in the vast territory between, it was largely the individual's responsibility to find care for injury or illness of any type.

Philadelphia, a medical center then, as now, had physicians, but neither a hospital nor a medical school. Persons coming to the city to consult the physicians found their own lodgings and nurses; the poorer permanent inhabitants, scattered about the city, depended on the charitable services of the busy physicians; in the steady stream of immigrants were many sick, those who succumbed to lengthy passage, crowded quarters and lack of fresh foods. At first, the sick immigrants were placed in vacant houses throughout the city, frequently resulting in spreading infection among the citizens (1).[2] To protect against epidemics arising from such sources, the authorities, in 1743, established the Pest House on Fisher's Island (an island then located on the site of what is now the Philadelphia Naval Ship Yard) as a sort of quarantine station (2).

As early as 1709 (3). Friends of the area realized the need of a hospital and their Meeting took some action toward securing a charter, but for some reason the objective was not attained, and so the establishing of the first hospital in what is now the United States awaited the maturity of two of Philadelphia's adopted sons—Dr. Thomas Bond, in 1709 as yet unborn, and Benjamin Franklin, then three years old!

Bond (4), born in Calvert County, Maryland, studied under a local physician, then travelled in Europe and spent much time in the hospitals of Paris. He started practice in Philadelphia when 20 years of age, and eighteen years later attempted to do something about the city's crying need for a hospital.

Franklin records, in his *Autobiography* "the proposal being a novelty in America and at first not well understood" his friend Bond "met but with small success" (5), and describes his own shrewd plan by which, in May

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[2] The boldface numbers in parentheses refer to the references appended to this paper.

1751, a charter and a conditional grant of £2000 was secured from the Colonial Assembly.

To cultivate the necessary public support, Franklin philosophized in the August 8th, 1751, issue of his *Pennsylvania Gazette:*

> . . . But the good particular men may do separately in relieving the sick, is small, compared with what they may do collectively; or by a joint endeavour and interest. Hence the erecting of Hospitals, or Infirmaries by subscription, for the reception, entertainment, and cure of the sick poor, has been found by experience exceedingly beneficial, as they turn out annually great numbers of patients perfectly cured, who might otherwise have been lost to their families, and to society. Hence infirmaries spread more and more in Europe, new ones being continually erected in large cities and populous towns, where generally the most skilful physicians and surgeons inhabit. And the subscribers have had the satisfaction in a few years of seeing the good they proposed to do, become much more extensive than was at first expected; for the multitude and variety of cases continually treated in those infirmaries, not only render the physicians and surgeons who attend them still more expert and skilful for the benefit of others, but afford such speedy and effectual instruction to the young students of both professions, who come from different and remote parts of the country for improvement, that they return with a more ample stock of knowledge in their art and become blessings to the neighbourhoods in which they fix their residence.
>
> It is therefore a great pleasure to all benevolent and charitable, who have been acquainted with these things in other countries, to observe, that an institution of the same kind has met with such encouragement in Pennsylvania, and is in such fowardness, that there is reason to expect it may be carried into execution the ensuing year. May the Father of all mercies grant it his blessing, and thousands of our unhappy fellow creatures, yet unborn, will have cause to bless him, for putting it into the hearts of the generous contributors, and enabling them thus to provide for their relief.

And again, on August 15th of the same year, Franklin wrote in his *Gazette:*

> . . . The difference between nursing and curing the sick in a Hospital, and separately in private lodgings, with regard to the expense, is at least as ten to one. For instance, suppose a person under the necessity of having a limb amputated, he must have the constant attendance of a nurse, a room, fire, &c. which cannot for the first three or four weeks be procured at less expense than fifteen shillings a week, and never after at less than ten. If he continues two months, his nursing will be five pounds, his surgeon's fee, and other accidental charges, commonly amounts to three pounds, in the whole near ten pounds; whereas, in a Hospital, one nurse, one fire, &c. will be sufficient for ten patients, the extra expenses will be inconsiderable, and the surgeon's fees taken off, which will bring the above calculation within the limits of truth.
>
> But the difference, with regard to the unhappy sufferer, is still greater. In a Hospital his case will be treated according to the best rules of art, by men of experience and known abilities in their profession. His lodgings will be commodious, clean and neat, in a healthy and open situation; his diet will be well chosen, and properly administered: He will have many other necessary conveniences for his relief, such as hot and cold baths, sweating-rooms, chirurgick machines, bandage, &c. which can rarely be procured in the best private lodgings, much less in those miserable, loathsome holes, which are the common receptacles of the diseased poor

that are brought to this city. In short, a beggar, in a well regulated Hospital, stands an equal chance with a prince in his palace for a comfortable subsistence, and an expeditious and effectual cure of his diseases.

It is hoped therefore, that whoever will maturely consider the inestimable blessings that are connected to a proper execution of the Hospital scheme in this city, can never be so void of humanity, and the essential duties of religion, as to turn a deaf ear to the numberless cries of the poor and needy, and refuse, for their assistance, a little of that superfluity, which a bountiful Providence has so liberally bestowed on them.

The resulting public subscription of over £2751 met the condition of the Assembly's grant and the project moved forward.

The first patient was admitted February 11, 1752 to the eight bed temporary hospital (6), and in the succeeding twelve months 54 patients were admitted.

The corner stone of the permanent building at the present location was laid with Masonic rites May 28, 1755 (7). It bears on its face the inscription by Benjamin Franklin (8):

IN THE YEAR OF CHRIST
MDCCLV.
GEORGE THE SECOND HAPPILY REIGNING
(FOR HE SOUGHT THE HAPPINESS OF HIS PEOPLE)
PHILADELPHIA FLOURISHING
(FOR ITS INHABITANTS WERE PUBLICK SPIRITED)
THIS BUILDING
BY THE BOUNTY OF THE GOVERNMENT,
AND OF MANY PRIVATE PERSONS,
WAS PIOUSLY FOUNDED
FOR THE RELIEF OF THE SICK AND MISERABLE;
MAY THE GOD OF MERCIES
BLESS THE UNDERTAKING.

The patients were moved into the new building December 17, 1756 (9). In the two centuries intervening, thousands of patients have found help within its walls, and as these words are written, "by the bounty of (current) private persons" its interior is being remodeled to facilitate the most modern care of today's patients.

A reading of the minutes of the early years impresses one with the managers' scrupulous regard for their responsibilities toward the patients, their ingenuity in stretching funds, their punctilious consultation with the medical staff on all matters directly affecting care of patients, and the steady increase in number of admissions; and on the part of the medical staff, their great interest in teaching and research, and their long tenures of charitable service.

Records for the first 50 years show the admission of 7135 "free" and 3213 "pay" patients, and that an unrecorded number of outpatients "received the advice of the physicians and the use of the medicines" (10). The most frequently listed diagnoses in this period were "ulcers with caries,"

"scorbutich and scrophulous diseases," "lunacy," "rheumatism and sciatica," "fevers," "venereal," "broken limbs." These terms were interspersed with such descriptive diagnoses as "a bad eye," "a hand shot off," "weak habit of body," "some finger bones decayed," "bad habit of body."

In spite of the early rule "That all persons who have been admitted into the Hospital, shall be discharged as soon as they are cured, or, after a reasonable time of tryal, are judg'd incurable (11), stays of two to four months are frequently recorded for all categories of patients—medical, surgical and "lunatick,"—and stays of a year or more were not uncommon.

Length of stay, and results obtained, concerned the Hospital then as now. When Franklin published his "Some Account of the Pennsylvania Hospital; From its First Rise, to the Beginning of the Fifth Month, called May, 1754" he appended to the patient statistics on page 36, this note:

> The Majority of the Lunaticks taken in had been many Years disordered, and their Diseases become too habitual to admit of Relief; others whose Cases were recent, and might probably have been cured, being put in at private Expence, were so hastily taken away by their Friends, that sufficient Time was not allowed for their Recovery: The Managers have therefore, as well for the Sake of the Afflicted, as the Reputation of the Hospital, resolved to admit none hereafter, who are not allowed to remain twelve Months in the House, if not cured sooner, or judged by the Physicians to be incurable.
>
> The Choice of the Sick to be supported on the publick Stock, was confined to such only whose Cases could not be healed properly in their respective Habitations, but required the extra-ordinary Conveniences and Advantages of an Hospital; amongst these, several, for want of this noble Charity in Time, had languished too long to receive any other Advantage from it than the Relief of their Poverty, and the Satisfaction of being convinced they had every Chance for Recovery that Care and Tenderness could afford.

Were we to carry on from this point and present to you figures representing hospital admissions and out-patients treated, at succeeding fifty-year intervals, the record would show a history of continual growth. Suffice to say the contrast would reveal that more patients are admitted in one single year today than were admitted in the entire first fifty years of the hospital's existence; and that from an "unrecorded number" of individuals receiving out-patient treatment we come to today's recorded number of more than 140,000 such visits in a single year in the Eighth Street Department alone.

The need for a hospital in this area was apparent to such men as Benjamin Franklin and Dr. Thomas Bond. To meet this need Pennsylvania Hospital was founded in 1751 through the combined efforts of medical and lay persons of that time. In succeeding years, the need, far from lessening, grew more and more great. New hospitals were founded. Pennsylvania Hospital, already an established and esteemed center, expanded its buildings, increased its staff, innovated new treatment, new teachings. In fact, whereas the original building provided quarters in the basement for the mentally ill, it was found inadequate and in 1836 additional land was pur-

chased in West Philadelphia for the establishment of a new Department for Mental and Nervous Diseases under the leadership of the great Dr. Thomas Story Kirkbride. No picture of today's hospital can be a "still life" drawing. It must, to truthfully portray the subject, be an "action shot." History is not made by standing still.

Contrast yesterday's medical terminology with today's. Records of the first fifty years again tell a story. The most frequently listed diagnoses of that period were given earlier in this paper. We refer them again to your attention. "Ulcers with caries," "scorbutich and scrophulous diseases," "lunacy," "rheumatism and sciatica," "fevers," "venereal," "broken limbs." These terms were interspersed with such descriptive diagnoses as, "bad eye," "a hand shot off," "weak habit of body."

In many instances these terms, used over and over again in early hospital records, were simply descriptive titles. By their very vagueness they convey a sense of groping, a feeling of the lack of knowledge behind their use. Had not men engaged in the practice of medicine been filled with a desire to know more concerning these ills and their treatment; had not facilities for study and experimentation been made available to them, these might well be the terms still in use.

Such men as Dr. Thomas E. Bond, who conveyed a dream to Benjamin Franklin (as a man who could translate it into action) realized the values in having the sick housed together. The opportunities this offered to young men in the study of medicine and in the practice of medicine were innumerable. Here, then, research had an opportunity to establish a foot-hold.

Two hundred and five years of history have been contributed to by Pennsylvania Hospital. Not the least, by far, of this contribution has been the part it has played in furthering the training of young men entering medicine. Important, too, have been the research programs started, carried on through facilities offered by the hospital, and completed in a manner further to shed light on medical problems. Today's research is concerned not only with medical problems of this present time, but with problems foreseeable, though not yet actually present. Nuclear research and radiation effect are still embryonic, yet in the light of today's and tomorrow's hopes and problems, they are important as a means of medical progress. So, today's Pennsylvania Hospital concerns itself with these problems among the many research studies underway.

Today's Pennsylvania Hospital is, as today's hospitals must be, a moving, working, vital force within a community. It is not enough that knowledge be gained within hospital walls. Interpretation of this knowledge to individuals who might ordinarily never have the opportunity to relate it to themselves is important. Out-patient clinics numbering more than fifty serve not only as treatment centers but as educational centers as regards community health. These same clinics function in co-operation with community practicing physicians. The tremendous amount of knowledge embodied in medicine today, coupled with the quantity, value, and intricacy of

equipment involved in diagnosis and treatment make it virtually impossible for a neighborhood practicing physician to own, house, and be proficient in the operation of all the necessary equipment needed for diagnosis and treatment. For this reason, today's hospital again assumes an important community role.

The one basically unchanging thing within Pennsylvania Hospital is an intangible, almost spiritual, force. From the date of founding, 205 years ago, the function of the hospital was based on "the care of the sick poor." Today those individuals in need of medical care, and unable to pay, either in full or in part, still may secure all necessary care at Pennsylvania Hospital. More than one million dollars worth of free medical care per year is received by "the sick poor." Progress must never out-distance the basic beliefs upon which the Hospital was founded. Care is taken that it shall not. The same administrative organization as was originally formed to set policy, plan procedure, and in general, oversee the functioning of the hospital is carried on today. A Board of Managers, composed of some of Philadelphia's most able business and professional men, give voluntarily of their time and energy.

As in Franklin's day, plans for the future of the hospital are worked out by the Board in close co-operation with medical and administrative members of the hospital staff.

The same far-seeing humanitarian motives that prompted an early Board of Managers to consider "lunaticks" as ill persons, in need of as careful and considerate care as any physically sick or injured individual, has been a factor in the decisions made by successive boards. The same spirit of looking ahead, and planning accordingly, that was prevalent in earlier groups of Managers, is present today.

Careful and judicious use of funds is as much a major problem today as in earlier days and has made possible a continued improvement program for hospital buildings, grounds, equipment, and training facilities. Improvements are made always with an objective of improving patient care.

Many of the medical problems the world of yesterday faced, are now either solved, or under medical control. The problems that still resist solution have today a growing battery of scientific knowledge and equipment turned toward mastering them. Problems, such as the great increase in mental illness, are being brought more and more to the attention of the public. Support from the public is necessary to provide the means whereby the necessary research studies, experimentation, equipment, and training of individuals, can be secured.

Pennsylvania Hospital has long been engaged in research in mental illness. Pennsylvania Hospital takes a just pride in the fact that great men of the past, such as Benjamin Franklin, played an important part in its founding. Pennsylvania Hospital personnel respect the basis on which these men established the hospital for, "the care of the sick poor"; and,

having pride in the past, they move with confidence through today, and remain alert for indications of future needs.

> Thus they that do good, not only do good themselves, but by their example are the occasion of much good being done by others.
>
> *Benjamin Franklin*

REFERENCES

(1) THOMAS G. MORTON, M.D., "History of the Pennsylvania Hospital," Revised Edition, Phila., 1897, p. 4.
(2) *Ibid.*, p. 5.
(3) *Ibid.*, pp. 4–5.
(4) *Ibid.*, p. 487.
(5) "The Autobiography of Benjamin Franklin," edited by Frank Woodworth Pine, Garden City, Garden City Publishing Co., 1916, p. 225.
(6) Pennsylvania Hospital Managers' *Minutes*, Vol. 1, p. 23.
(7) THOMAS G. MORTON, M.D., "History of the Pennsylvania Hospital," Revised Edition, Phila., 1897, p. 39.
(8) Pennsylvania Hospital Managers' *Minutes*, Vol. 1, p. 177.
(9) *Ibid.*, p. 225.
(10) *Annual Reports*, Pennsylvania Hospital.
(11) Pennsylvania Hospital Managers' *Minutes*, Vol. 1, p. 39.

"It is undoubtedly the Duty of all Persons to serve the Country they live in, according to their Abilities; yet I sincerely acknowledge, that I have hitherto been very deficient in this Particular; whether it was for want of Will or Opportunity, I will not at present stand to determine: Let it suffice, that I now take up a Resolution, to do for the future all that *lies in my Way* for the Service of my Countrymen."

Dogood Papers—April, 1722

FRANKLIN AND THE UNCONQUERED FIELDS OF MEDICINE*

BY

PIERRE LÉPINE, M.D.[1]

Académie nationale de Médecine

There is perhaps no field of interest where Benjamin Franklin's love of humanity and inventive spirit are more clearly revealed than that of medicine. We find indeed in his life and works an absolute evidence of his deep interest in medical matters, though having made no specialized study of the subject. We know also of his efforts in the awakening of his contemporaries' feelings toward the problems of public health, as well as his activities toward the alleviation of human suffering.

There is one period of his life where we see this direct contact with medical problems to which he contributed as much help as he could give. This participation took place toward the end of his life when as a world famous figure he was ambassador plenipotentiary for the young American Republic. For nine years as a resident of Paris he headed an historic mission, keeping close contact with European scientific circles.

In 1776, during the very month of June when the Declaration of Independence was formulated, Congress decided upon a resolution submitted by Richard Henry Lee and seconded by John Adams, "That it is expedient forthwith to take the most effectual measures for forming foreign alliances."

Subsequently this resolution was adopted on July 2nd, proclaimed on July 4th; and following the unfailing course of historical events Franklin, a major witness of the birth of the new nation, was appointed the following autumn to go to France with Silas Dean and Arthur Lee to work there for an alliance and military support from the king. The American colonists were at the time insurgents, struggling with varying success to obtain the recognition of their right to be free from England. Their fate was uncertain but their cause attractive. Certainly no one better than Franklin could represent them in France where *Poor Richard* enjoyed a tremendous popularity as the prototype of the new American: practical, ingenious, full of hard-working common sense; yet of a civic and humanitarian bend; a serene philosopher, realistic, yet not so much so as to exclude some idealism and a taste for adventure.

Franklin, accompanied by his two grandsons, set out secretly on October 26 aboard the armed sloop "Reprisal." The voyage was a strenuous one,

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* Paper submitted in French.

[1] Member, Académie nationale de Médecine; Institut Pasteur, Paris, France.

the sea was heavy, and high winds blew them dangerously close to the blockading English fleet. The mission disembarked at Nantes where the enthusiastic welcome which Franklin and his companions received was nothing compared to the one which they were to have in Paris in December. This was the beginning of a sojourn which was to last until July, 1785.

It is well known how Franklin, having taken up residence in the village of Passy in a house which Le Ray de Chaumont had lent him, began, with Vergennes as intermediary, fruitful negotiations with the French government which were to culminate in the French alliance and in the effective participation of France in the War of Independence. Also well known is the popularity he enjoyed in Paris, and his universal success. His house at Passy was a rendezvous for the French intelligentsia and huge crowds rushed to pay him tribute. Everyone of note in the domain of letters, sciences, and high society felt it necessary to associate with Franklin and to entertain him at home, to read and comment upon his works, and to ask his opinion on current problems as well as on the most abstract questions of philosophy. Physicians figured prominently among those who considered Franklin's least words as oracles.

In 1777, Franklin, who had maintained relations with all French scientists and with the celebrities of the Parisian medical profession and was, as early as 1772, a member of the Académie royale des Sciences, was elected to membership in the Société royale de Médecine, already widely known as the Académie de Médecine. Two letters safely kept in the archives of the library of the Académie nationale de Médecine which, after the French Revolution succeeded the Société royale de Médecine, show us the interest which Franklin took in their meetings. These are addressed to Vicq-d'Azyr, the Queen's physician, at the time permanent secretary of the Society. One of them dated March 1st, 1784, is in French, dictated to a secretary and signed by Franklin. It is an acknowledgment of the receipt of books and documents which had been sent to him for his own personal reference. The other is a letter entirely in Franklin's hand, dated September 11, 1780 and written in English, in which he excuses himself for having not attended one of the Society's meetings because of the state of his ill health caused by kidney stones, an affliction which brought on his death ten years later.

Meetings were held in the Louvre Palace in the section of the building which faced the Rue du Coq, a street which no longer exists, where the Société royale de Médecine had its headquarters, and where the permanent secretary resided. The minutes of the meetings show us that Franklin participated in these on a great number of occasions and spoke his mind on the much-discussed problems related either to public health, such as the organization of hospitals or the danger of disinterments, or to the use of medications such as mineral water baths, electricity, or cantharides preparation.

Numerous documents from the same period attest not only to Franklin's popularity in scientific circles, but also to the active interest which he

showed in medical problems during his sojourn in France. He is most frequently referred to, moreover, as Doctor Franklin although he did not hold a medical diploma.

Further proof of Franklin's great interest in medical matters is found in his works, not only in the devices which his ingenious mind led him to invent to aid suffering humanity such as bifocal spectacles or the flexible catheter, but also in the numerous remarks which fill his books and his correspondence, remarks in which he reveals his interest in studies on the circulation of blood, and in experiments investigating the causes of lead poisoning. Elsewhere he proposes the medical utilization of electricity for the treatment of paralyses or he denounces the dangers of infections caused by polluted waters. Also he sets forth his ideas on the contagion of common colds and influenza by thrusting aside the common notion of the necessary relationship between these afflictions and the action of cold or dampness considered as exclusive cause.

Franklin's eternally aroused critical mind led him in the same way to question the action of vesicatories on fever or the effectiveness of the then proposed medications for dissolving urinary calculi. As a result of this critical spirit, equally replete with common sense and good judgment, Franklin was in 1784 appointed by the Académie to a committee created to investigate Mesmer's theories and the disorders of all sorts which Mesmerism had given rise to in Paris. The decision handed down by the commission which culminated in the formal condemnation of Mesmer, is full of Franklin's very spirit, who, without denying the reality of observed physical phenomena, defines the limits of their interpretation and retains only logical deductions, casting aside the excesses of the imagination.

It is important to remember also that Franklin, who lost a son from smallpox, was a passionate proponent of vaccination in Pennsylvania.

There is no doubt that Franklin, confident of the progress made by the sciences and of the scientists' ardor for ameliorating the lot of humanity, whole-heartedly believed in the continual and unlimited progress of medicine culminating in the total victory of man over disease. To that effect, from his house at Passy, he wrote to Priestley, in 1780: "All diseases may by sure means be prevented or cured, not excepting even that of old age, and our lives lengthened at pleasure even beyond the antediluvian standard".

It is therefore probable that Franklin would have greeted with equanimity the medical revolution of the XIXth Century and the progress of contemporary medicine. But can we say in this respect that the dream which he perceived in his letter to Priestley has come true?

If Franklin were to come back among us, what changes would he find in medical pathology and in the evils which still crush suffering humanity! Franklin's medical opinions as well as his research, reflect the dawn of biological sciences, when philosophers were beginning to apply to the study of man and his physiological problems the methods of observation which had permitted the advent of exact sciences. Medicine, long in the

empirical stage, was going to profit from the rapid advances made in physiology since the end of the XVIIIth Century and base therapeutics not only on clinical observation but also on physio-pathological foundations drawn from the study of the healthy as well as the diseased organism.

Less than a century after Franklin, a man was to come who, moved like Franklin with an insatiable curiosity, driven by a genius consisting of logic, common sense, and strictness of observation, was to discover the microbic origin of infectious diseases and teach the world the way to prevent them. In the field of medicine, the second half of the XIXth Century was completely taken over by the revolution which Pasteur caused, a revolution whose first effects are even now only being noticed by us, for, if it has put an end to the great scourges which had been ravaging humanity since the dawn of time, at the same time it has made possible the prodigious increase in the population of the world with all the consequences which that has already entailed in the farthest domains of medicine and public health.

Thus, medical science of today is profoundly different, therefore, from medicine in Franklin's time, first of all by the disappearance of the principal infectious diseases as the predominant cause of mortality, then by the advances in physiology and physiopathology which have permitted the doctor to re-establish the physiological metabolic or humoral equilibrium whose disorders characterized numerous diseases, finally by the advances in hygiene and pediatrics which have more than doubled the life expectancy of the newborn baby, without mentioning the recent developments of chemotherapy and antibiotics.

Smallpox, cholera, plague, yellow fever, and exanthematic typhus have been eliminated as agents of devastating epidemics. If the germs which cause these infections have not completely disappeared from the face of the earth, they have been controlled and remain localized in certain areas from whence they can spread only by or following wars but their outbreaks are then stemmed by effective prophylactic measures.

Scurvy, pellagra, rickets, deficiency diseases, the main endocrine disorders have today been conquered and have practically ceased to be major diseases among peoples where a balanced and satisfactory diet, coupled with medical supervision, allow timely intervention and the compensation of diet deficiencies or endocrine disorders.

Infant mortality has continued to decrease regularly and we can foresee a time when it will be reduced to the inevitable minimum representing congenital malformations incompatible with life and what hazards may remain after the reduction of obstetrical risks.

If in the realm of infectious diseases, the classical scourges are no longer of consequence among the favored peoples whose standard of living has benefitted the most from the advances realized in the course of the last hundred years, other infections represented by virus diseases have appeared and are spreading in spite of measures taken up to now. A disease like poliomyelitis thus appears to be the ransom for hygienic progress and the

cruel countermeasure which Fate opposes to a better care for earliest infancy. And already, even before poliomyelitis may be regarded as definitively vanquished, we can see the growing frequency of infectious neurotropic localizations as well as the menacing increase of viral encephalides, seasonal or not, with the host of sequelae which characterize them.

The various cardiac diseases and the cardio-vascular diseases not only seem to be increasing in a relative but also in an absolute degree as a result of the conditions of life and the over-exertions which characterize the life of modern man. Rheumatism with its localizations and far-reaching consequences is taking an increasingly large part in the pathology of civilized beings, which modern therapeutics with endocrinology and chemotherapy have not yet reduced to a significant degree. Congenital malformations and hereditary afflictions, all sorts of disorders which affect the genetic stock and which are perpetuated in the family manifest themselves with an increasing frequency and seem destined to encumber the entire human race in the long run, with the further factor of the mutilating influence of radioactive products which for the past ten years have been loosened in growing numbers in the environment of human existence.

But of all the scourges which remain to be conquered, unquestionably the most disquieting is represented by cancer whose incidence shows an alarming increase equally due to its growing relative importance and to determining factors whose absolute value increases incessantly for civilized man.

If early diagnosis, surgery, and therapy by ionizing radiations allow the malady to be arrested in a certain number of cases and to be cured when it has been stopped, if hormonotherapy and chemotherapy offer valuable resources to slow down and arrest the growth of certain tumors, the fact still remains that cancer is responsible for one third of adult mortality and that this rate is increasing regularly on a sinister curve while the ultimate cause still escapes us and the prophylaxis of the malady is scarcely outlined.

In the exploration of the domain of cancer, several promising paths are today open for us, but we have only begun to explore their possibilities and we cannot yet be sure of possessing the thread which will lead us to the definitive solution.

Side by side with normal, as it were, pathology where we can observe a sort of natural evolution conditioned by the discoveries and advances of medicine which, by eliminating certain causes of sickness, leaves a clear field for others, we must recognize a completely new pathology created by man and for which he is directly responsible.

The development of industry and the evolution of urban civilization have brought about professional diseases, physiological and pathological disorders which were formerly rare or unknown. In the same way that by discovering the fortunate isles of the Pacific the navigators of the XVIIIth Century, so completely impregnated with the spirit of the philosophers that they believed they were contributing to the welfare of the primitive peoples,

brought them tuberculosis, syphilis, deadly measles, alcoholism and decadence, similarly modern civilization with its excessive industrialization, its sprawling cities and its poisoned atmosphere has created problems which we call housing, transportation and nutrition. These problems which man must solve and which most of the time he solves only thanks to expedients rebound with evil effects upon the health of the individual and the community.

The rising tide of mental diseases, from chronic instability or psychasthenia to delirium and dementia seem to us to be the ransom paid by humanity to modern urban civilization in exchange for material advantages whose benefits more often than not remain illusory.

Already man has reached the limits of his physiological capacities in a great diversity of fields, and more and more he must rely upon automatons to supplement his failing faculties. He has shortened distances and time, freed energy from matter, but the creations of his genius only bring out the fragility of his brain, the limits of his resistance and the inescapable consequences of his insubordination to the laws of nature.

There is, therefore, a field left to conquer which not only concerns medicine but also involves social causes which have a profound influence upon public health.

If Franklin were to return among us, he would without a doubt marvel at the advances realized in the realm of sciences and of medicine in particular, but with his common sense and innate love of man, he would also be amazed to see that, in many cases, material progress, with all the possibilities and prospects for betterment which it brings with it, has too often helped to enslave the men it intended to free, and increased their hardships where it could have eased their burden.

Such problems are both man's challenge to medicine and a threat to all mankind by a fraction of humanity. If Franklin were to return among us, without a doubt he would feel the need to write a little book on the present aspects of medicine into which he would place in a humorous way the best of his wisdom and where he would find the way, by denouncing the evil, to stimulate the ardor to discover its remedy.

The lesson he gave us must not be lost. Confronted by the problems which medicine and civilized life present to our minds today, let us remember his words, now perhaps more appropriate than ever: "We may make these Times better, if we bestir ourselves."

BENJAMIN FRANKLIN, THE FREEMASON

BY

WILLIAM J. PATERSON[1]

Free and Accepted Masons

Benjamin Franklin, as a young man of 24 years, months before he had ever passed the tiled portals of any Masonic Lodge, unwittingly rendered a service to the Grand Lodge of Pennsylvania and Pennsylvania Freemasons in General, greater in fact than any other person connected with our history.

While in London, 1725–26, the young printer had undoubtedly learned something about the Craft, the membership of which was then almost exclusively confined to the nobility and gentry, and which was attracting more or less attention in the public prints. The knowledge thus obtained, whether orally or from the publications of the day, limited and vague though it must have been, appears to have quickened the ambitious philosophic brain of the young printer upon the subject of Freemasonry, and whetted his desire to be numbered amongst the elect; an ambition not to be realized under existing conditions, as he was then still under the lawful Masonic age and a journeyman printer, a virtual stranger in the community, and, as a mere soap-boiler's son, lacking both social and financial standing.

This applies to him during his sojourn in London, as well as in Philadelphia, at this period.

Upon his return to Philadelphia, this desire became even stronger when he learned that a Lodge had either been set up here, or was contemplated by the resident Brethren.

In the year 1727 Franklin organized a secret society of his own known as the "Leather Apron Club"—a name itself suggestive of our Fraternity.

In 1731, the name of the Club was changed, and the character of the Club was also revised, so as to become a purely literary one and took the name of "Junto." Its chief element, "secrecy" patterned after the Masonic Fraternity, was, however, retained, otherwise it became literary in character, or as Franklin himself wrote "a club for Mental improvement."

The eventful outcome of this club, running side by side as it were, with the Craft, was the formation of the Library Company of Philadelphia in 1731 and the American Philosophical Society in 1743, in both of which Franklin was the leading spirit.

Benjamin Franklin achieved his ambition to become a Mason in February of 1731. Here he performed one of his finest services to Masonry and to people everywhere.

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The great French Ambassador, Jules Jusserand, once said of Franklin:

> He taught us something we have never forgotten—equality . . . that no man should have a better chance in this world because he happened to be born in some certain caste or class.

Benjamin Franklin brought this principle to the Grand Lodge of Pennsylvania and with it the Democracy and Equality for which Free Masonry is noted throughout the world.

As a matter of fact, it was within the Masonic Lodge at Philadelphia, where Franklin had the first oportunity of learning parliamentary usage by actual practice or occupying any position of authority and government. Consequently, it is but fair to assume that here in St. John's Lodge, and subsequently in the Grand Lodge of Pennsylvania, was laid the foundation of Franklin's future greatness as a parliamentarian and a prominent figure in all the many and various organizations with which he became identified during his long and active public career. Further, it is an indisputable fact that the offices conferred upon Franklin by the Grand Lodge of Pennsylvania, of that early day, were the first public honors held by the great Printer and Statesman.

To write the history of Franklin as a Freemason is virtually to chronicle the early Masonic History of America.

Early in the year 1731, we find that the young printer was Entered, Passed and raised to the Sublime Degree of a Master Mason in St. John's Lodge, held at the Tun Tavern in Water Street, Philadelphia. The cost of his entrance fee was three pounds sterling.

The published records of the Craft in his newspaper known as "The Pennsylvania Gazette" supplant the early minutes of this Lodge long since lost or destroyed.

His connections with St. John's Lodge give us an insight into the financial affairs of early Freemasonry, as found in the yellowing pages of "Liber B." His services as Grand Master and later as Provincial Grand Master are closely interwoven with the early Masonic history of this Jurisdiction. During the later years of his life he had an active Masonic career in France. There, his activity and intimacy with the Brethren was intimate and close, both personal and official, even advancing to the so-called higher degrees.

The Masonic career of Benjamin Franklin extends over a period of almost sixty years, during which time he was accorded the highest Masonic honors at home and abroad.

1730–1 February, initiated in St. John's Lodge, Philadelphia.
1732– June, drafted a set of By-Laws for St. John's Lodge.
1732– June 24, elected Junior Grand Warden.
1734– June 4, elected Grand Master of Pennsylvania.
1734– August, advertised his "Mason Book," a reprint of Anderson's "Constitutions of the Freemasons," the *first* Masonic Book printed in America.

1734–5 The State House (Independence Hall) built during Franklin's administration as Grand Master. According to the old Masonic and family traditions, the corner-stone was laid by him and the Brethren of St. John's Lodge.

1735–8 Served as Secretary of St. John's Lodge.

1750– March 13, appointed Deputy Grand Master by William Allen, Provincial Grand Master.

1752– March 12, appointed on Committee for building "The Freemason's Lodge," on Walnut Street between Second and Third Streets, Philadelphia.

1752– October 25, visited the Tun Tavern Lodge, Philadelphia.

1755– June 24, took a prominent part in the Grand Anniversary and Dedication of the "Freemason's Lodge" in Philadelphia, the first Masonic building in America.

1760– Provincial Grand Master of Philadelphia.

1760– November 17, present at Grand Lodge of England, held at Crown & Anchor, London. Entered upon the minutes as "Provincial Grand Master."

1762– Addressed as Grand Master of Pennsylvania.

1776– Affiliated with Masonic Lodges in France.

1777– Elected member of Loge des IX Soeurs (Nine Sisters or Muses).

1778– February 7, assisted at the initiation of Voltaire in the Lodge of the Nine Sisters.

1778– November 28, Officiated at the "Lodge of Sorrow" or Masonic Funeral Services of Voltaire.

1782– Elected Venerable (W.M.) of Loge des IX Soeurs, Grand Orient de Paris.

1782– July 7, member R L de Saint Jean de Jerusalem.

1785– April 24, elected Venerable d'Honneur of R. L. De Saint Jean de Jerusalem.

1785– Elected honorary member of Loge des Bone Amis (Good Friends), Rouen, France.

1786– December 27, in the dedication of a sermon delivered at the request of the R. W. Grand Lodge of Pennsylvania, by Rev. Joseph Pilmore in St. Paul's Church Philadelphia, Franklin is referred to as "an illustrious Brother whose distinguished merit among Masons entitles him to their highest veneration."

1790– April 17, Benjamin Franklin passed to the Grand Lodge above.

1906– April 19, memorial services at his grave in Christ Church yard, S. E. corner Fifth and Arch Streets, Philadelphia, by the officers of the R.W. Grand Lodge of Pennsylvania, the occasion being the two hundredth anniversary of the Birth of Benjamin Franklin.

". . . there is no Rank in Natural Knowledge of equal Dignity and Importance with that of being a good Parent, a good Child, and good Husband or Wife, a good Neighbour or Friend, a good Subject or Citizen, that is, in short, a good Christian."

Letter to Miss Mary Stevenson
London, June 11, 1760

FRANKLIN'S IMPETUS TO EDUCATION

BY

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"Experience keeps a dear school but fools will learn in no other and scarce in that" (1, p. 225)[2] as Poor Richard said. In many ways, Benjamin Franklin was a prototypal American, more so than most of the aristocratic Founding Fathers of our country. He was the lineal cultural and intellectual forebear of such persons as Abraham Lincoln and Will Rogers. He was a person primarily of the deepest common sense and practicality with which he combined such versatility of interest, zeal for social and self improvement, resourcefulness, competence, and a host of other elementary virtues as to set him off uniquely among the persons who were influential in educational matters in the Colonies. His extraordinary gifts as a homespun aphorist derived from a sharpness and incisiveness of mind which made his counsel constantly in demand in the 18th Century, and his homilies have become so much a part of our language that when he is quoted people think more often than not that this polished wisdom has come from either Holy Writ or the Bard of Avon. His role as sage and ultimate pragmatist of the Colonies had a marked influence upon the development of educational enterprises, particularly in the neighborhood of Philadelphia.

He himself had very little schooling, having been as he says, "put to the Grammar School at eight years of age, my father intending to devote me as the tithe of his sons to the service of the church." (1, p. 11.) A person familiar with Franklin in later life would have counseled Josiah Franklin against an ultimate profession so little likely to be congenial to his son. Even such elementary preparation was curtailed for, as he says, "I continued, however, at the Grammar School not quite one year, though in that time I had risen gradually from the middle of the class of that year to be at the head of it, and farther, was removed into the next class above it in order to go with that to the third at the end of the year." (1, p. 12.) It is unlikely that the nature of the Grammar School education in Massachusetts was such as to appeal particularly to Franklin, for it would seem that he always valued independent progress and self improvement above all forms of teaching. He himself at an early age developed that fondness for books which characterized his whole life, and in fact, he says that he could not remember the time when he could not read. Though he was not particularly

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[2] The boldface numbers in parentheses refer to the references appended to this paper.

drawn to a collection of sermons proffered him by his Uncle Benjamin, he laid out what money came into his hands for *Pilgrim's Progress*, R. Burton's *Historical Collections*, and other books of such substance which took his fancy. Being ashamed of his ignorance in figures which had been a trial to him in school, he himself worked through Cocker's *Book of Arithmetick* plus two books on navigation and geometry. He wrestled by himself with Locke's treatise *On Human Understanding*, with Greenwood's *Grammar*, and with Xenophon's *Memorabilia of Socrates*, and the Socratic method proved such strong medicine at this early age that he describes in some detail the nuisance he made of himself to his elders in practicing the method upon them.

In the course of formulating his thoughts upon the proper method of educating others he, in his customary fashion, framed his views most succinctly. "If you wish information and improvement from the knowledge of others and yet at the same time express yourself as firmly fixed in your personal opinions, modest, simple men who do not love disputation will probably leave you undisturbed in the possession of your error." (1, p. 22.) He also quotes with approbation Pope's couplet:

> Men should be taught as if you taught them not
> And things unknown proposed as things forgot. (1, p. 22.)

Such sentiments were quite typical of one who was constantly casting about for ingenious ways of affecting others and the point of view recurs frequently in his advice on educational matters. His emphasis on self improvement rather than on formal education is evident in his attitude toward the educational value of travel and conversing with the congenial men of thoughtful temperament whom he met. He was constantly on the look-out for profitable information and to learn from the unfamiliar ways of others. Although avid for new experiences, this tendency was tempered with a characteristic caution and a skepticism which never left him and which sieved out of his daily experiences those matters which he set in orderly fashion among his mental furniture for future use. The source of information for which he had the greatest regard was his own first-hand observation, and in this he was certainly the Colonial father of experimental science. In his letter to John Lining, of Charleston, he describes at length his observation on cooling by evaporation; and his observations of many other physical phenomena, particularly those relating to electricity, are classical items in the history of science (2, pp. 111–112). His skepticism in regard to his fellow men was such that he seemed able to place wholehearted reliance only in Nature herself. All other matters which came to him were viewed in the light of his worldly wisdom with a most critical eye. As Henry Steele Commager has said, "He was suspicious of metaphysics and skeptical even about skepticism where it didn't work; thus he cheerfully abandoned materialism reflecting that this philosophy, tho' it might be true, was not very useful!" (1, p. viii.)

Benjamin Franklin's utilitarian point of view in the matter of education is well illustrated by his remarks on the study of foreign languages. In his typical fashion, he began to study languages at the age of about twenty-seven, mastering French, Spanish, and Italian. On looking into a Latin Testament after gaining his acquaintance with the Romance languages, he was surprised to find how much Latin he could understand, and, as would have been anticipated, this excited his curiosity and speculation. Being told that one should study Latin first, he inquires why, in point of priority, one should not begin with Greek instead, and he gives some practical thought to the cases of those persons who having begun Latin do not continue on to the modern languages and thus, in his view, waste precious time without adding another tongue to their repertoire. The outlook upon the language of Cicero as a mental discipline would not have been congenial to this practical Colonial, for he likens Latin to that final product of millinery evolution, the Chapeau Bras, which no longer served a useful purpose as a head covering but was merely carried under the arm. "The still prevailing custom of having schools for general education of our children these days teaching the Latin and Greek languages I consider therefore in no other light than as the Chapeau Bras of modern literature." (3.) What did not pay its way or pull its weight in Colonial daily affairs was better left at home and not carried as a burden, at least by the simple men of Pennsylvania.

His point of view on economics can be inferred from Poor Richard's views on thrift, which indeed make up a large part of that worthy's epigrams. "There are no gains without pains"; "Industry pays debts while despair increases them"; "Diligence is the mother of good luck"; "Keep thy shop and thy shop will keep thee." He did, however, go so far as to acknowledge the role of the supervisor in: "The eye of the master will do more work than both his hands." (1, pp. 217–221.) The management of currency was something about which he had considerable first-hand experience, having done very well indeed in the printing of it on several occasions. He was under no illusions about paper money and were he to have observed the steady course of inflation during the past 250 years, he would, I believe, not have been surprised. Indeed, Poor Richard remarks, "If paper money in ever so growing quantity could be made, no man could get any of it without giving something for it, but all he saves in this way will be his own for nothing and his country actually so much the richer. Then the merchants' old and doubtful debts may honestly be paid off and trading become surer thereafter if not so extensive." (1, p. 211.)

Though he obtained degrees of Master of Arts from Yale College and the College of Cambridge in New England for his discoveries in the electrical branch of natural philosophy, he remarks rather slyly, "Thus without studying in any college I came to partake of their honors." (1, p. 146.) Nor does the letter from that good dame, Silence Dogood, concerned with her satirical fancy of the Temple of Learning, indicate any very high regard for organized higher education in the Colonies. The libelous comment

that many of the inhabitants of the Temple of Learning are "poor as church mice, being unable to dig, ashamed to beg, and to live by their wits it was impossible" (1, p. 202), represents a most unsympathetic point of view toward that College of New England which was later to honor him for his electrical investigations.

Benjamin Franklin, however, was very honestly and sincerely concerned with what he regarded as the true intellectual welfare of his countrymen, and he was particularly instrumental in rescuing the first foundation of what was later to become the University of Pennsylvania from the incompetent hands of its earliest trustees. In 1739, an itinerant Anglican clergyman, George Whitefield, came to preach in Philadelphia, and his evangelical gifts were such that he not only acquired a great following but also alienated the occupants of the regularly constituted pulpits in the city. In 1740, the two objects, a free school and a building in which Whitefield or any other visiting divine could preach, were combined under the trusteeship of certain artisans, and a building was erected on a tract of land at 4th and Arch Streets. The educational use of this building, however, lagged and the abilities of the trustees were insufficient to maintain the venture so that in its ninth year, a group of persons of position and responsibility in the city, acting largely under the inspiration of Franklin, took it over and established an academy which was so well and firmly conceived that it grew as the educational center of the Philadelphia settlement. Franklin's role in this undertaking was the initial and promotional one, growing out of his pamphlet, *Proposals Relating to the Education of Youth in Pensilvania,* printed in the year 1749. This he distributed among the principal inhabitants gratis, thereby crystallizing local concern for a school in the Colony. His non-sectarian background provided the qualification to the other quarreling representatives of the Protestant sects for his being named a member of the trustees of Mr. Whitefield's building, and largely through his good offices he brought about a union between these trustees and the persons concerned with the new Academy in order that the affair would have the joint support of both groups and also the use of the building initially constructed for visiting divines. He drew considerable pleasure from his later association with the trustees of the Academy which enjoyed contributions from Britain and the Proprietaries and grew into the "College of Philadelphia." In his autobiography, he says that he has been one of its trustees "for now forty years and have had the great pleasure of seeing a number of the youth who have received education in it distinguished by their improved abilities, serviceable in public stations and ornaments to their country." (1, p. 135.) The latter somewhat rhetorical benefit undoubtedly bulked less significantly for him than the very practical benefits which youth received from the institution which he had been so influential in establishing.

The pamphlet which instigated the Academy begins with the sentence, "The good education of youth has been esteemed by wise men in all ages as

the surest foundation of the happiness both of private families and commonwealths." (3, p. 5.) This sentence would be as appropriate today as it was when it was written, and it would probably find an even larger percentage of adherents among Americans in the 20th Century than among Franklin's early Colonial neighbors.

In order to bring about this good education upon which social and political wisdom would depend, Franklin proposed that some persons of leisure and public spirit should undertake to organize and encourage the foundation of an Academy and oversee its operation under the direction of a rector who should be "diligent and patient, learned in languages and sciences and a correct pure speaker and writer of the English tongue." (3, p. 9.) Nor did he neglect the role of bodily health in his Academy, for he advocated the strengthening of the students' bodies by running, leaping, wrestling, and swimming. As to the study which should go on in this Academy, he advocated learning those things which are "likely to be most useful and most ornamental." (3, p. 11.) Among these he included the writing of a fair hand, mechanical drawing, arithmetic, geometry, and astronomy, and even adumbrated the university's future interest in business and finance by suggesting that the students be taught accounts. The English language should be taught as should French, German, and Spanish, and while those persons intended for divinity should learn Latin and Greek, others should not be compelled to spend their time in this way. History was to be a particular concern in the curriculum and should be taught not from the point of view of learning the curiosities of ancient cultures, but with a view to learning from the mistakes of others in order not to commit those same errors again. He would also have geography taught in order that the students could read maps; morality in order that the causes of the rise and fall of man's character could be made clear and the virtues of temperance, order, frugality, industry, and perseverance strongly inculcated in the youth of the Colony. Also, he was sure that history would show the wonderful effects of oratory in turning and leading great bodies of mankind. An appreciation of this by the young men of Philadelphia might permit them to appreciate and practice this art and also, to some extent, immunize them against subversive politicans and demagogues. In fact, history had so much to teach in the advantages of liberty, the benefits of good laws and due execution of justice, and the inculcation of the principles of the Christian religion, that it was to be the keystone of his curriculum. Nor would he have the simpler manual arts omitted from his school. Natural history would have its place, but emphasis would be placed on gardening, planting, grafting, and other forms of husbandry; "The improvement of agriculture being useful to all and skill in it no disparagement to any." (3, pp. 27–28.) He concludes his essay by saying, "With the whole should be constantly inculcated and cultivated, that Benignity of Mind, which shows itself in searching for and seizing every Opportunity to serve and to oblige; and is the Foundation of what is called Good Breeding; highly useful to the Pos-

sessor, and most agreeable to all. The Idea of what is true Merit, should also be often presented to Youth, explain'd and impres'd on their Minds, as consisting in an Inclination joined with an Ability to serve Mankind, one's Country, Friends and Family; which Ability is (with the Blessing of God) to be acquir'd or greatly encreas'd by true Learning; and should indeed be the great Aim and End of all Learning." (3, pp. 29–30.)

Franklin's concern for education was by no means confined exclusively to its application in the early years of youth. He was one of the earliest and most practical advocates of adult education in America, and in the autumn of 1727, he formed what he called his most "ingenious acquaintance into a group of mutual improvement which we called the Junto." (1, p. 67.) That this was no group of dilettantes or amateurs in educational theory who found congeniality over the flowing bowl is attested by the original name of the group as the "Leather Aprons." These gentlemen met weekly on Friday evenings, and in accordance with the rules drawn up by Franklin, each member in turn had to write essays and address the group on some practical and improving topic in the fields of morals, politics, or natural philosophy. The discussions and debates were to be factual and inspired by the true spirit of inquiry and were not to be considered as occasions for the expression of personal prejudice nor as opportunities for self-assertiveness by members; these contingencies were minimized to such an extent as human nature is pliable by the imposition of "pecuniary penalties." This association of twelve friends lasted some forty years and must indeed have been a source of great intellectual stimulus to the members. Franklin characterized it as "the best school of philosophy, morality, and politics that then existed in the province." (1, p. 69.) This venture into the area of adult education bore the impress of two of Franklin's particular convictions; namely, the paramount value of practical matters and the great virtue of learning by direct personal effort and participation. Members learned to master various subjects and to speak to good purpose upon them as well as to enjoy the give and take of intellectual discussions and to profit by the well considered and defended views of others. The Junto was the forerunner of the American Philosophical Society which continued and expanded this educational technique for the benefit of its members.

Franklin's views undoubtedly had a very direct effect upon the development of educational programs and institutions in the Colonies, but the truly remarkable extent to which our system of education today embodies the principal points of view which are evident in Franklin's writings represents rather the extraordinary degree to which Benjamin Franklin was the prototypal American.

The United States has set a greater store by its educational system, has invested more money in it, and has expected more practical benefit from it than any other country in the world. We have the same high regard for education as a benefit to the citizens of a democracy that Franklin had, and we use many of the same empirical criteria for success in this venture that he himself would have used. Illiteracy in the United States has declined

from about thirty per cent a century ago to something under three per cent at present, and this is directly attributable to the breadth of base which has been accorded education in this country in complete harmony with Franklin's views on our social and civic responsibilities. Public school enrollments which were fifteen million at the beginning of the century are twenty-six million today, and this represents nearly eighty-five per cent of the children from seven to fifteen years of age. The number of teachers in the same period has more than doubled to approximately a million in 1954, and total school expenditures have risen in the same half-century by a factor of thirty. Though many people are still dissatisfied with the quality of our primary and secondary education, such judgments will always vary and there can be no question but that the opportunities for education exist for any boy or girl in the United States, and that an overwhelming proportion of these boys and girls take advantage of this opportunity to the great benefit of the social and intellectual standards of our country.

Franklin was concerned not only with broad self-improvement for the citizens of the nation but most particularly with a practical and useful type of instruction from which students could acquire a knowledge of those skills and trades which would furnish their own livelihood and contribute to the industrial and commercial welfare of their communities. Vocational education has received particular emphasis in the United States. The Federal Government has contributed nearly one dollar out of every five expended for those aspects of vocational education eligible for such assistance. Twenty-five years ago, about one-half million students attended vocational schools, most of these studying trade and industry, though home economics and agriculture each represented a significant fraction. Today nearly three and one-half million students are enrolled in federally aided classes. The trade and industry and the agriculture programs each account for about one-fourth of this total and home economics for about one-half. We are not only teaching young citizens useful trades, but we are extending our vocational interest toward the distaff side of our citizenry to an extent which I am sure would have both surprised and delighted Franklin.

Our college and university populations have increased even more strikingly in the past century, and the total enrollment is now well over two million, one-third of whom are women. The type of curriculum which these students encounter is as different from that in the New England colleges of Franklin's day as is the attitude which these students bring to their educational opportunities. At the University of Pennsylvania, which Franklin founded, the requirement of Greek was abolished by 1914 and by 1930 a student could graduate without having studied either Latin or Greek in college. This is typical of other institutions; the classics no longer occupy the pre-eminent position in higher education that they did in Franklin's day, and Franklin would have found himself in sympathy with the shift in emphasis to the modern languages that has occurred. The criteria by which our curricula are judged may be less pragmatic than Franklin would have urged, but we might rationalize this as desirable latitude in our interpretation of

what is useful rather than as condoning the merely ornamental among the subjects to be found in the catalogues of our schools. It is almost impossible to think of any trade or calling, the rudiments of which cannot be learned in one or another of our institutions, but the great emphasis which has characterized American education in recent generations has been the rise of the technical institutes and of engineering and technical education in general. The programs of our technical schools, of course, include the humanities, as Franklin would have wished, with emphasis upon composition, the organization of one's ideas, and the setting forth of these both orally and in writing. History is likewise included in the curricula of these schools, and I believe that Franklin would have approved of the point of view commonly encountered in the exposition of this subject. Likewise, the practical matters of economics and finance receive their emphasis. The concentration, however, is upon the sciences, which are subjects of practical and demonstrable worth to the student and to his community as judged by any of the criteria Franklin would have employed. These subjects are learned in laboratories in which the students participate directly with their own hands, learning from the phenomena themselves without the interposition of teachers or commentators. As an experimental scientist himself, Franklin would have approved most highly of this system of education, and the integration of teaching and research which characterizes our university and technical institutes is again a development which would have been most congenial to this Colonial exponent of learning-by-doing and continuing the educational process throughout one's whole life.

It would be interesting to speculate upon Franklin's attitude toward the social sciences and their place in our current educational system. That he had some appreciation of statistical method and could make shrewd deductions based upon its use is indicated by his "Observations concerning the Increase of Mankind, People of Countries, etc." (4). I believe he would have given unqualified approval to the practical and objective elements in these disciplines. On the other hand I am equally sure he would have been careful not to extend theory beyond a reasonable relation to fact and he would have slyly exposed those who fatuously use words and phrases borrowed from physical and biological science in attempting to give unwarranted authority to their discussions of human values and relationships.

Franklin would have been well aware that current concepts in the emerging social sciences dealing as they do with the infinite variables of human nature are necessarily complex and less well defined than many of the controlling hypotheses in natural science. He might well have concurred in the caution which Frederick T. Gates presented to John D. Rockefeller, Jr., when the Rockefeller Foundation was considering entering the field of the social sciences. "When you come to investigate these things you are not acting on inert matter or even on animals. Can you command this material as you can command the material of investigation in medical science? I fear not." (5.) He was too rigid in his logic, as well as too empirical in his approach, to be guilty of any pretended scientific au-

thoritarianism in intellectual areas where the concepts do not lend themselves to procedural definition and where there are many logical pitfalls for the unwary. Probably Franklin would have winced at the overconfident implications of certainty in the use of the term "social science." This mental discomfort might well have stimulated his fabulous ingenuity to devise a term more appropriately emphasizing the description and analysis of human behavior and the assessment of its controlling values which are the central concerns of these disciplines.

We in the United States have been particularly distinguished by our concern for the continuance of educational opportunities for those who have passed beyond the ordinary years of schooling. There are correspondence courses, "great books" movements, and local scientific and literary societies of all types. Most of the large universities have extensive programs in adult education, and our natural bent toward education together with the greater leisure which modern generations have enjoyed has developed educational opportunities for those of riper years far beyond those to be found in other generations or other countries. This would likewise have been a development close to Franklin's heart, and he would have thought of the Junto as the initial experiment in this field and the one which showed his fellow countrymen the opportunities inherent in such gatherings of congenial persons concerned with mutual improvement in philosophy, morality, and politics.

The happy phrases with which Franklin closes his essay on the education of youth in Pennsylvania could be read again by us all with great advantage. Our educational system is already clearly imbued with the principles of service to mankind, one's country, friends, and family, and an avowed object of this system is the inculcation in each individual of the desire and ability to render this service. Franklin also spoke of acquiring that "Benignity of Mind which shows itself in searching for and seizing every Opportunity to serve and to oblige." (3, p. 29). We can show less progress toward this ideal, but like the commandment to love one's neighbor as oneself, it is a beacon light by which we could well set the future course of our educational policies.

REFERENCES

(1) "The Autobiography of Benjamin Franklin and Selections from His Other Writings," with an introduction by Henry Steele Commager, New York, The Modern Library, 1944.

(2) "Benjamin Franklin's Autobiographical Writings," edited by Carl Van Doren, New York, The Viking Press, 1945.

(3) BENJAMIN FRANKLIN, "Proposals Relating to the Education of Youth in Pensilvania" (Facsimile Reprint with an Introduction by William Pepper), Philadelphia, University of Pennsylvania Press, 1931.

(4) "Observations Concerning the Increase of Mankind and the Peopling of Countries, Etc.," *The Works of Benjamin Franklin*, compiled and edited by John Bigelow, Vol. II, New York, G. P. Putnams Sons, 1904, pp. 338–350.

(5) RAYMOND MOLEY, "Scientism," *Newsweek*, June 28, 1954, p. 88.

"I think with you, that nothing is of more importance for the public weal, than to form and train up youth in wisdom and virtue. Wise and good men are, in my opinion, the *strength* of a state far more so than riches or arms, which, under the management of Ignorance and Wickedness, often draw on destruction, instead of providing for the safety of a people. And though the culture bestowed on *many* should be successful only with a *few*, yet the influence of those few and the service in their power may be very great. Even a single woman, that was wise, by her wisdom saved a city.

"I think also, that general virtue is more probably to be expected and obtained from the *education* of youth, than from the *exhortation* of adult persons; bad habits and vices of the mind being, like diseases of the body, more easily prevented than cured."

Letter to Samuel Johnson
Philadelphia, August 23, 1750

FOOD AND THE FUTURE

BY

D. P. CUTHBERTSON[1]

The Royal Society of Edinburgh

The Royal Society of Edinburgh is proud this day to remember the great contributions to knowledge made by its Honorary Fellow, Benjamin Franklin. To him the cultivation of the earth was "the most honourable of all employments, the most useful in itself and rendering man the most independent." To-day the world's greatest physical need is to increase her production of food for her rising population and so to improve the quality of that food that it ceases to be a limiting factor for health. The topic of food and the future is probably the most important of all topics for it concerns the future survival of mankind.

PRESENT POPULATION TRENDS AND PRESSURE

It is reckoned that there are some 2500 million people in the world. Their health, morale and productive energy are largely dependent upon the available food. In many parts of the world, native communities live at subsistence level, for the climate, topography and infertility of the land require that nearly all the people are involved in growing food. Under such conditions, output is small and the amount of food produced is also affected by the health of the people.

The major effect of the modern public health programme has been to reduce mortality occurring before the reproductive period of life and to extend the expectation of life at birth to 63 years. In the underdeveloped two-thirds of the world it is 30 years.

In countries like China, Egypt and India where the average expectation of life at birth is in the neighbourhood of 30 years, only 54 out of every 100 children born ever reach the age of 15 and enter the period of maximum economic productivity (1).[2] Of those who reach young adulthood all but 15 die or are incapacitated long before completing the normal span of working life to 63 which is the life-expectancy at birth in the developed areas of the world. In these latter areas 92 out of every 100 children born reach the age of 15, and 70 live a productive life span to 63. Reduction of the death rate in the underdeveloped areas will mean an increase in the human resources available for production in proportion to population. It is surely

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[2] The boldface numbers in parentheses refer to the references appended to this paper.

wise to use such natural resources as exist for the support of those who produce as well as consume, rather than largely for those who are not permitted to reach the age at which they begin to make their contribution to their society.

People can and should be enabled to live longer for the factors which controlled primitive populations in the past are largely being eliminated, and intertribal wars are no longer permitted. Disease is as never before capable of being brought under control.

The most recent WHO statistics suggest that the process of industrialisation as experienced in Europe is not now quite so predictable as to its effects on people's reproduction, for, though initially increased prosperity is normally associated with lower reproductive rates, birth rates have risen in Britain, France, Sweden and U.S.A. The figures (2) are higher than those available for India and Japan. It seems dangerous therefore to generalise. The fundamental solution to the problem of population lies in increasing the productivity of the individual by putting at his disposal modern scientific knowledge and the tools of modern technology. To the extent that this is done, every individual can become a source of new wealth to his country and to the world (3). By education it should be possible to help men and women to live fuller and happier lives in adjustment with their changing environment.

The unequal distribution of population and resources over the earth affects the character of the national diet. Countries having one to two and a half acres of cultivated land per head can produce all or nearly all of the necessary food but the quality of the dietary, in particular the amount of meat and fat, depends on the efficiency of their agriculture (4). Into this group fall Western and Central Europe, except the United Kingdom, Belgium, Holland and Switzerland. North and South America, Australia, New Zealand, Eastern Europe (except Czechoslovakia) and the U.S.S.R. have each 2½ acres or more per head. Countries listed as marginal are Austria, Czechoslovakia, Italy and Western Germany which have only about one acre per head. This could give them a physiologically adequate though monotonous dietary, but they all can export something wherewith to purchase imported food and so obtain a better dietary than they themselves produce.

Countries with two and a half or more acres of cultivated land per head usually produce a surplus of food for export (4). These are the lands to which the rest of the world looks when food supplies are short. But the surplus has to be purchased.

Countries with less than one acre per head of population could with some difficulty produce a physiologically adequate dietary but it would be mainly or wholly vegetarian as the production of animal food requires much more land than that for vegetable food (4). The countries in this group fall into two categories: those with mixed dietaries and those with predominantly vegetarian dietaries. The United Kingdom, Belgium, Holland

and Switzerland have developed international trade on a sufficient scale and character to induce countries with a surplus to supply them with the foods they need: they can therefore maintain a mixed dietary of rather high quality. India, with about 0.8 acre per head, China on about 0.5, Japan on less, cannot do this; they have largely eliminated meat from their dietaries and live almost entirely on vegetable foods though where there is available water, fish are used. For all countries in this group there is an element of precariousness, for any breakdown in production may lead to serious shortages. About two-thirds of the world's population grow their own food, and probably about 80 per cent live in rural areas in which the food consumed has all been grown locally (4). The remaining 20 per cent—some 450 to 500 millions—are dependent to a greater or less extent on food transported from a distance.

Taking the world as a whole and 1980 as a date—for official estimates of population increases for that point of time are now available—then the supplies of cereals—the most important of staple foods—will need to be increased by 43 per cent to feed the extra mouths at recent levels, while a further increase of about 10 per cent would be required to feed them at an improved level according to Rao and Amaral (5). The relative increases are even greater in the case of the protective foods, for example, according to the calculations of these two experts, fish supplies would have to be increased by 88 per cent, while milk supplies would need to be raised by about 70 per cent to attain the improved levels.

It has been pointed out that such global assessment of needs conceals the great disparity between different regions in their need for extra food (5). For example, supplies of cereals in the Near East will have to be increased by 78 per cent to reach the improved level while the corresponding figure for Europe is only 22 per cent. For milk supplies in these two regions the figures would be 81 per cent and 45 per cent, respectively.

The provision of the quantities of foodstuffs required for consumption in the underdeveloped countries calls for a vastly greater effort than is envisaged by their peoples at present, and frequently there is no technological reason why food production cannot be raised to the indicated order of magnitude.

Whether one be pessimistic or optimistic by nature, the only positive policy towards population trends and natural resources must be constructive effort towards solution. What can be done under sudden pressure of population can be seen in Israel at the present time, where each year nearly 2000 trained persons leave agricultural and engineering colleges to take up work in various aspects of food production for the population of one and a half millions living in just under 8,000 square miles of territory. Even the smallest settlement has at least one member who has been trained and there is excellent interchange of information and enthusiasm to make the desert yield food (6).

THE WIDER CONSEQUENCES OF HEALTH PROGRAMMES

Diseases are often a direct deterrent to exploitation of natural resources and to industrial development. The removal of disease has been likened to the discovery of a new land. The result of malaria control means that crop production can be increased and the jungles can be cleared. Malaria control in a district in Eastern Pakistan not only diminished infant mortality but increased the production of rice by 15 per cent from the same acreage ("more and better hands to work") without any improvement in methods of cultivation or variety of rice (7). This increase was due to the fact that whereas in the past three out of every five land workers had been sick of the fever at the critical seasons of planting and harvesting, five out of five were available for the manual operations when the malaria had been controlled. In other areas removal of seasonal malaria has made it possible to grow a second crop. Egypt's loss of $60 million a year through bilharziasis is proportionately much greater because the disease is a determining factor in a low economy (7). As the incidence of disease is reduced so man can effectively use to the full what should be his allotted lifespan and even when he is ageing work appropriate to his reduced capacity should come within his reach. Thus poverty is reduced because people are better able to develop their resources and improve their social lot and become to a greater extent masters of their environment.

Education becomes worth while when people survive to use it. Only an enlightened people can take full advantage of the services provided: a disease-ridden malnourished people can neither provide nor enjoy the amenities of education.

PATTERN OF DEVELOPMENT

A balanced and sufficient diet will generally provide a more resistant community and reinforce the fight against parasitism. Such a diet is often of more importance than complete control of endemic disease.

In developing large areas of previously uncultivated land or in changing the type of cultivation, it is essential to find out the many facts relating to the climate, the terrain, the physical and chemical nature of the soil, the customs and habits of the people, the lines of communication, and the potential threats to the proposed crops. As many plant diseases are intractable, it is necessary to have a plant-breeding programme related to research on resistance to disease and on yield. The jungle need not always win.

Agricultural production is to some extent seasonal and the level of consumption by man or beast depends greatly on the farmer being able to harvest his crops freed from weeds, disease and parasites. Stretching of the cropping and breeding season so as to spread the food supplies over the year, together with methods of conservation increase production. Primitive methods of harvesting frequently lead to high losses. The rat, the weevil and other organisms by their depredations reduce substantially the products of harvest,

so also does faulty collecting equipment. Recent departmental studies in the United States (8) show that despite all the gains made in agricultural production, $13 billion a year are lost because of insects, diseases, parasites, weeds, inadequate harvesting, mechanical damage, weather and similar hazards. If by some magic this loss had been eliminated it would have required 120 million fewer acres to produce the equivalent of last year's production. Even if only 50 per cent efficiency was reached this would in effect "reclaim" vast areas for our use. Boosting crop yields through better use of fertilizers will also effect a "reclamation."

In animal husbandry the use of antibiotics has opened up considerable possibilities for increased animal production.

In the United States there is a great future for such crops as hybrid sugar beets and grain sorghum. Shaw (8) looking ahead finds no reason on the basis of preliminary research, why we cannot breed crop varieties that will resist several of many diseases, insects, nematodes and weather hazards. There are already wheat varieties that combine resistance to leaf rust, loose smut and Hessian fly. Small grain breeders are also crossing wheat with rye in an effort to get into wheat the resistance of rye to cold.

There is no reason why disease resistance cannot also be bred into animals. Strains of birds that resist fowl paralysis, pullorum disease and typhoid exist.

The pattern adopted by the British Colonial Office is the result of much trial and error and has, so far, proved most useful (9). Where a research finding must be applied, it is best attempted at different departmental trial grounds throughout the territory concerned. Where a particular crop must be tested in the environment where it is to be grown, then it is best tested at a commodity research station. Such stations are generally situated in areas where single commodities such as rubber, sisal, tea, coffee, oil palm, cocoa and rice, are grown. Where it is a case of research into fundamental principles concerning soil, plant, animal-plant relations, the results of which can be applied over large areas, this is best carried out at a regional research station. Where the research involves long-term survey work, it may be apportioned to a department specially set up for that purpose. If the research involves investigation into a disease or insect pest which has become dominant in a particular territory, it may be entrusted to an *ad hoc* unit recruited from existing research organisations. With all this, there must also go forward education, technical and cultural, and guidance to wise statesmanship.

It is improbable that extension northwards of the frontier of cultivation will offer to the world any large proportion of the benefit to be gained by bringing the tropics under domination, since the environmental conditions for growth in the high latitudes are much less favourable though very slowly becoming more favourable than they were as witness crops being grown now in southern Greenland. By the development of mixed farming based upon adapted cereals, forage crops and a dairy industry, and with the use of

substantial amounts of lime and mineral fertilizers, the podzol zone, principally in the U.S.S.R. and to a lesser extent in Canada, can be expected to give a fairly large production of those crops and animal products for which the abundant potential resources of the tropics are less suited (10).

The milk yield of dairy cows, and the rate of growth of beef cattle, can be improved by selective breeding and better management. In the United Kingdom, for example, the average yield of dairy herds varies from below the national level of 660 to over 1000 gallons a year. If all the inferior stock were graded up to the level of the best, and preventable diseases like tuberculosis eliminated, the present milk supply could be maintained with 30 per cent fewer cows. The OEEC has recently reported that the yield of 50 million acres of pasture land in Europe could be increased by 40 per cent. All these means of increasing the supply of milk, dairy products, and beef are being applied in many countries though at far too slow a rate. In the United Kingdom in the last twenty years or so, the yield of pastures on the more progressive farms has been increased by over 50 per cent by better management, the augmented and more economical use of fertilizers, and the more economic use of grass for winter feeding, by grass drying and the making of silage. If this can be done in Western Europe where dairy farming is at as high a level as anywhere in the world with the exception of New Zealand, it is obvious that it is physically possible to increase the world supply of milk and beef by nearly 100 per cent on the land at present cultivated or grazed. By better management or feeding and by control of disease the yield per head of pigs and poultry could also be greatly increased.

An analysis of livestock production indicates that resources and technical bases exist for certainly not less than five times the present world output (10).

In Western Europe, where the humus content of the soil is well maintained and balanced fertilizers are generally used, the yield of wheat averages about 22 cwt. per acre; but on the best-run farms, it is 30 cwt. or more. In most of the wheat-growing areas of the world, including North America and Australia, it is little more than half this amount (11). It is abundantly evident that in India and Pakistan, by using fertilizers, especially nitrogen, by the extension of composting and green manuring to put humus into the ground, and by the use of seeds of higher yielding strains, the yield of food could be greatly increased. Improved methods of agriculture could play a major role in bridging the gap between a yield of 10–15 bushels of wheat per acre in India and China and 40 bushels per acre in Western Europe, as between 26 bushels of rice per acre in India and 76 bushels per acre in Japan (12). The addition of boron and manganese to the soil has increased peanut crops in the Gambia fourfold at little expense. The introduction of hybrid maize in Italy has increased crops by a third to double the yield. It has been estimated that per acre yields of grain in India could be increased by 30 per cent in ten years—5 per cent by use of improved varieties, 20 per

cent by manuring, and 5 per cent by protection from pests (11). FAO set as its target an increase of 90 per cent in the caloric yield of the less developed areas by 1960, an increase which could not only provide for probable population growth but also for material rise in standards of living.

It is no exaggeration to say that agricultural science, if applied to the land in the spirit in which Franklin applied his scientific knowledge, could double the world's food supply from the land already in cultivation.

It happens that those areas which offer greatest promise of increased agricultural development are precisely those areas now handicapped by preventable disease. For example, a former Director-General of FAO, Dodd, saw that Africa could offer major possibilities for future development, yet 4½ million square miles of fertile land are reckoned to be idle because of sleeping-sickness.

Further extensions of world agriculture are vividly emphasized by Milner (13) who has pointed out that at present (*a*) less than 10 per cent of the earth's land surface is cultivated—the rest largely waste; (*b*) only about one-tenth to one-half of 1 per cent of the sun's radiation received at the earth's surface is fixed as organic material—the rest is lost; (*c*) only about half or less of the organic material ultimately reaches the table as human food—much of the rest is wasted. Milner has calculated that taking the earth's surface as a whole, for each million calories of energy received from the sun only one calorie is converted into human food.

Though gigantic schemes of water conservation are afoot for some of the arid parts of the world, they are as nothing compared with what is needed, for water is the factor finally limiting food production. In many parts of the world the more acreage yields are increased, the more it is likely that water, not land, will become a most serious limiting factor—in humid as well as in dry climates.

Irrigation experts estimate that in the U.S.A. water is only probably used to 35 to 55 per cent of efficiency. There is no valid reason why this should not be 80 per cent. Good fertilizer practice and good irrigation go hand in hand.

THE FOOD AND AGRICULTURE ORGANISATION

Interallied recognition that the causes of war largely stem from lack of food elevated the problem to supra-national status following the last World War and called forth an international organisation in the Food and Agriculture Organisation of the United Nations, which is dedicated to the expansion of food production, particularly by advising underdeveloped countries so to overcome their environment that they improve their agricultural productivity.

The ultimate goal of all of FAO's work is to enlarge human wellbeing by increasing and improving production, distribution of food and other products of agriculture, forestry and fisheries. It is concerned to know better what good nutrition is and what it requires. When the needs are

known it is next necessary to know the area and capabilities of the world's land with its related water supplies and cover of forest and grass and to know its aquatic resources. In order that resources are used most productively with due regard to their conservation there is need to improve seed stocks and animal strains; to improve the tools and methods of agriculture, forestry and fishing; to protect the production from ravages of pests and disease; and to improve the methods of storage and processing into useful products.

First, there is the study of needs from the physiological standpoint—the determination of human requirements for calories and nutrients. Second, the estimates of requirements must be compared against estimates of consumption, to determine whether the food supplies of countries and regions are sufficient for needs. With the easing of the food situation some change in attitude has taken place. Attention is being paid not only to enough food but to provide food of the right kind.

The higher level of food production has brought improved quality of diet in countries of relatively high consumption and some increases in consumption of staple foods in countries where consumption is low. In many areas food consumption has not kept pace with increasing production. Farm prices have eased appreciably but not retail prices to the same extent. This factor has helped to account for the appearances of surpluses of some foodstuffs in North America and the difficulties experienced by Far Eastern exporting countries in disposing of rice supplies. Thus there is now need for selective expansion. But one of the most effective methods of surplus disposal, least disruptive of marketing procedures, is to channel foods into a supplementary feeding programme, the object of which is to improve the nutrition of vulnerable groups. But in the long run the improvement of the nutrition of vulnerable groups must depend mainly on increased supplies of locally produced foods, but of the right kind.

Cassava meal (manioc) is the staple food of many native populations in Africa and elsewhere, and covers practically all their caloric requirements, but it is particularly low in protein and high in carbohydrate. The quality of the protein is also low. When the natives for whom cassava is the staple foodstuffs—in particular young children—are examined, the most striking disorder is kwashiorkor, a name first given to the condition by Dr. Cecily Williams in 1933 (**14**), which has its chief characteristics: (*a*) retarded growth in late breast-feeding, weaning and post-weaning periods; (*b*) alteration in skin and hair pigmentation; (*c*) oedema; (*d*) fatty infiltration of the liver; (*e*) heavy mortality if better and more protein is not supplied. Although the etiology has not yet been fully established, many regard it as due to protein deficiency, particularly just after weaning (**15**). Dean (**16**) found that concentrated milk protein gave best results but mixtures of plant proteins were also effective. Others bring evidence to show that the freedom from kwashiorkor which is enjoyed by many large vegetarian countries may depend on nothing more profound than the suitable mixing of plant

materials in the diet. If this is correct it indicates a relatively easy method of prophylaxis and adds strength to the hope that the cure of this disorder in the tropics will not depend on a supply of animal protein, for that would be wellnigh impossible meantime. The examination of other sources of protein indigenous to the areas where children's diets are poor and the condition of kwashiorkor abounds is in progress. In order to attack protein malnutrition successfully, further information about its prevalence in different parts of the world is needed.

FAO and UNICEF have been cooperating in developing what have been called "local food projects." The object is to encourage, in countries in which the immediate prospects of developing a satisfactory dairy industry are poor, the use of other foods which can improve child nutrition. Among these is fish flour. We are as yet only at the very early stage of development of river, loch, pond, lagoon, dam, reservoir, and even flooded rice field in fish-farming. Who can say where breeding and genetics, nutrition and management will eventually lead us in this field. The actual ploughing up of the bottom muds of lakes, if not even of the seas, is even now in an experimental stage and might revolutionize the exploitation of aquatic resources. The collection of plankton has often been advocated.

Edible fish meal, or fish flour, falls into the category of cheap, transportable animal protein for underdeveloped countries. The basic material is inexpensive, the protein content high and the processing low in cost. It contains 60–85 per cent protein. In properly manufactured fish meal, that is, fish meal made from fresh fish offal, the originally high biological value of the protein will be retained. In particular, fish meal proteins are rich in certain essential amino acids otherwise scarce in most cereal diets characteristic of underdeveloped regions—for instance lysine. Moreover, fish meals if properly manufactured, will contain calcium and phosphorus, and vitamins of the B group, mainly riboflavin and B_{12}.

FAO is endeavouring to find fish flours sufficiently flavour-free to be used for incorporation in a number of foods, such as bread flour (**17**). The first experiment of FAO with flavourless fish flour has been completely successful in Chile using a bread roll containing 10 per cent of the fish flour. The bread was slightly darker in colour; smell and taste, and form and consistency of crust and crumb were normal. The United Nations Children's Emergency Fund (UNICEF) has been following this work with great interest and is setting aside a certain sum of money to be spent on similar fish flour trials under the auspices of FAO and UNICEF in Ecuador, Mexico and Peru and with extensions of the Chilean experiment.

Plans to enrich wheat flour with soya flour to increase its nutritive value are being planned in Israel. Further work in processing protein-rich foods is being undertaken in the Near East, the Far East, Latin America and the Pacific.

The joint FAO/WHO Expert Committee on Nutrition has pointed out that "legislation governing preservation, nomenclature and acceptable food

standards often varies widely from country to country. New legislation not based on scientific knowledge is often introduced and little account may be taken of nutritional principles in formulating regulations. The conflicting nature of food regulations may be an obstacle to trade in foodstuffs between countries."

Some, apprehensive of the future balance between numbers of mouths and food to fill them, have been looking for new sources of food. Attention has been paid to leaf protein, mainly by Pirie (18), and to micro-organisms such as yeasts by Thaysen (19) and to the alga *Chlorella* investigated by Spoehr and Milner in California and later by others, as sources of protein and fat. Present indications are that the cost of production of microbial products and synthetic fats (Williams (20)) are higher than if the equivalents were obtained through ordinary agricultural practice. The economics of extracting and processing leaf protein which seems to be of high biological value, have still to be determined.

Synthetic vitamins and individual amino acids are being used in some of the more highly developed countries to supplement foodstuffs, particularly in animal husbandry where industrial and agricultural waste products are sometimes utilised in considerable amount in the compounding of feedstuffs. In these circumstances it is essential to secure a restoration of nutrient balance in relation to the class of stock being fed.

Pirie (18) has drawn our attention to the fact that by Midsummer Day we have had about half the total annual sunshine and scarcely any of it has been used by the frost-sensitive crops such as potatoes because the air is too cold for them. Little has been used even by the frost-hardy grasses because the ground is too cold for effective growth. Much more is now being done in more northerly latitudes to extend the outdoor grazing season by selection of strains of grasses which will provide good leaf production throughout the year when suitably grazed.

CONCLUSION

If present knowledge were fully exploited a world population of 6000 millions could probably be supported; but it is unlikely that such a figure will ever be reached (11). Modern science has already in part the answer to the problems that worried Malthus: indeed he did not doubt that an answer would be forthcoming, but some of his successors have. What is needed is that advances be pressed with vigour and understanding now to save the future.

The anachronism of vast populations leading lives steeped in poverty and ill health in a world where "a thousand secrets of mastering nature, of increasing productivity, of prolonging life, of liquidating want, are practised and known" (21) can and must be removed by the people themselves through their energy and purpose, technically aided by those who have already profited by such improvements. This can only be secured if there is also

an adjustment of mental attitudes towards lasting peace throughout the world with freedom of its peoples from want, disease and fear. This was the essence of Benjamin Franklin's prayer some two centuries ago.

REFERENCES

(1) C. E. A. WINSLOW, "The Cost of Sickness and the Price of Health," WHO., Geneva, 1951.
(2) World Health Organization, Epid. vital Statist. Rep. 7, p. 305, WHO., Geneva, 1954.
(3) Food Agricultural Organization, "World Food Survey," 1944.
(4) E. J. RUSSELL, "World Population and World Food Supplies," London, Allen & Unwin, 1954.
(5) K. K. P. N. RAO AND C. J. AMARAL, "Population and Food Requirements," World Population Conference, Rome, 1954.
(6) J. YUDKIN, *Chem. & Indust.*, Feb. 14, p. 140 (1953).
(7) UNITED NATIONS, "Preliminary Report on the World Social Position," United Nations, New York, 1952.
(8) B. T. SHAW, *Agric. Food Chem.*, Vol. 2, p. 725 (1954).
(9) G. A. C. HERKLOTS, *Chem. & Indust.*, Feb. 14, p. 136 (1953).
(10) W. H. PAWLEY *et al.*, "Possibilities of Increasing the Supply of Food and Agricultural Products by Exploitation of New Areas and Increasing Yields," World Population Conference, Rome, 1954.
(11) J. BOYD ORR, "The White Man's Dilemma," London, Allen & Unwin, 1952.
(12) W. C. BURNS, "Technological Possibilities of Agricultural Development in India," Lahore, India, 1944.
(13) H. W. MILNER, *J. Amer. Oil Chemists*, Vol. 28, p. 363 (1951).
(14) C. D. WILLIAMS, *Arch. Dis. Childh.*, Vol. 8, p. 423 (1933).
(15) J. F. BROCK AND M. AUTRET, "Kwashiorkor in Africa," FAO Nutritional Studies No. 8, Bull. World Hlth. Org., Vol. 5, p. 1 (1952).
(16) R. A. DEAN, "Plant Proteins in Child Feeding," Spec. Rep. Ser. Med. Res. Coun., Lond. No. 279, 1953.
(17) Food Agricultural Organisation, "The Work of FAO," FAO, Rome, 1953/54.
(18) N. W. PIRIE, *Chem. & Indust.*, May 9, p. 442 (1953).
(19) A. C. THAYSEN, *Chem. & Indust.*, May 9, p. 446 (1953).
(20) P. N. WILLIAMS, *Chem. & Indust.*, June 13, p. 582 (1953).
(21) V. L. PANDIT, Proc. United Nations Scientific Conference on the Conservation and Utilization of Natural Resources, 17 Aug.–6 Sept. 1949, Vol. 1, p. 425, New York, 1950.

"Since the foolish part of mankind will make wars from time to time with each other, not having sense enough otherwise to settle their differences, it certainly becomes the wiser part, who cannot prevent those wars, to alleviate as much as possible the calamities attending them."

Letter to Edmund Burke
Passy, October 15, 1781

FRANKLIN, THE BUSINESSMAN, FIRST GREAT APOSTLE OF FREE AND COMPETITIVE ECONOMY ON THE AMERICAN SCENE

BY

MARION L. MUSANTE[1]

The Philadelphia Contributionship for the Insurance of Houses from Loss by Fire

Benjamin Franklin, a printer by trade, an individualist at heart, and a successful businessman in every sense of the word, has gained the reputation of being the first real exponent of free enterprise on the American scene. And what is "free enterprise"? The term has as many meanings as there are writers to define it, but the designation on which all seem to agree, in essence if not in degree, is "liberty in business." Liberty gives one the right to perform any moral action so long as it does not trespass upon the rights of another; when another is injured, liberty becomes license and license is unacceptable as a code of social behavior.

The War of the Revolution was fought to secure for all persons liberty to practice personal ingenuity, to labor or to trade for the purpose of improving themselves. With final victory the people of this young nation gained for themselves both liberty and equality of rights and privileges. It was no mere coincidence that prompted the colonists to guarantee this newly-won freedom by adopting the republican form of government, for under this system the supreme power rests in all the citizens entitled to vote and is exercised by representatives chosen directly or indirectly by them and responsible to them. Thus, government "of the people, by the people, for the people" recognizes the basic principles of economics: that all people must labor; that someone must conserve; that risks must be hazarded; that some are leaders and more are followers; that all men, whether leader or follower, must be rewarded. This, in essence, is the system that provides the best atmosphere for liberty in business—free enterprise.

The American form of government, as outlined in the Constitution of the United States, has provided the best environment for the progress of free competitive business, which, in its turn, has given to the people of America more conveniences and better standards of living, more advantages and more opportunities to command those advantages than any other nation of the world has had in any period of history.

The average American of today, then, is not average if judged by the standards of the rest of the world. It is estimated that those earning $5000 annually can be rated among the top one per cent of the world's wage earners.

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Tradition has not bequeathed to modern man a fool-proof system of economics, and, when one considers the age of the world, the science of applied mathematics is in its infancy. However, history does proffer some guiding principles on free enterprise from which practicable applications may be deduced. Clearly the inviolability of man must never be defiled. Nations that have been built upon the exploitation of one group for the benefit of another have sooner or later faced upheaval. Rome's slaves revolted; the feudal system crumbled when the serfs asserted their human rights; America needed a Civil War to excise the canker; and France was brought to her knees by the French Revolution. In our own times, the suppression of the peoples under Communist control results in a vast police force, costly in men and money to the government. It could inaugurate a rebellion which ultimately may be the downfall of Communism itself. Conversely, when human dignity is honored, foundations are sound.

In America, our forefathers realized—and Abraham Lincoln aptly stated it for them—that man receives his value from God and sets a value on everything else, including government. The economic order is, therefore, fixed by man: his production and collection of goods and his demand and consumption of them create that order. History has permitted no laggards: although it is quite true that some have dissipated their birthrights and others have lived on the fruits of their neighbor's labor—and today it is not difficult to find examples of both in industry and government—yet, by and large, such exploitation can continue only for a comparatively short time before ruin or rebellion balances the scales.

Inherent in man's ideals is a moral code which has been translated into civil law. It is wrong to steal; the Romans punished it by cutting off the hand. It is just as wrong to steal a man's labor by underpaying him. The converse is also true: it is wrong to cheat the employer of time and effort and to weaken the employer's business through a lack of responsibility, abuse of tools and equipment, or disloyal attitudes. Franklin said, "establish a character as an honest and faithful as well as skilful workman, and then he need not fear for unemployment" (1d, p. 16)[2] and " . . . take care to make it faithfully and never slight manufacture or attempt to deceive by appearance. Then he may boldly put his name and mark . . . " (1d, p. 16). It is equally unjust to insist that the employer divide all his profits among the workers, for the business man is entitled to compensation for his investment of money, for providing employment for his workers, and for the risk he takes as an entrepreneur. Further, he is entitled to an additional share to be used as a reserve on which he can call in times of stress. It is management's province to conserve capital, one of America's most valuable possessions. It must see that capital is efficiently used in production, conserved against depleting practices, and kept fruitful in results. For carrying out this responsibility to society, management deserves to be paid.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

Benjamin Franklin cannot be termed an historian in the sense that he reverted to history for the source of his moral attitudes. His advice on economics is based on material and human wisdom, although he never directed it against established government nor did he attack the existing social order. However, his entire writings extol those virtues that formal religion and history bring to our attention and he used them as the cornerstone to the attainment of his own personal success. One finds in *Poor Richard's Almanac* nothing but advice on moderation, morality, and frugality. Franklin says, "My father taught me that nothing was useful which was not honest" (1d, p. 12), "Remember industry, frugality and prudence" (1a, p. 24), and again "Work as if you were to live 100 years, Pray as if you were to die Tomorrow" (15, p. 32).

Franklin's main purpose in publishing the *Almanac* was to convey instruction to his readers. In his *Autobiography* he says, "I therefore filled all the little spaces that occurred between the remarkable days of the calendar with proverbial sentences, chiefly such as inculcated industry and frugality, as a means of procuring wealth, and thereby securing virtue." His ideas on morality are clearly defined here, for, to paraphrase it, industry and frugality result in wealth, which is synonymous with virtue. Such a materialistic philosophy cannot be acceptable to a people who recognizes the dependence of man on his Creator and man's responsibility to obey the laws of the Creator. Its fallacy is borne out in fact, for the industrious and frugal are not always wealthy nor can they be said consequently to be lacking in virtue.

Franklin's philosophy is a trader's philosophy; it is opportunist, utilitarian, and harsh. It stresses saving for the sake of saving and forgets that a people does not become great merely through acquisition but rather through the freedom of every citizen to exercise to the fullest his God-given talents. At Poor Richard's door we may also lay the blame for the dilatory progress of the American arts, because it permits no leisure for thought or recreation and thus stultifies human development. In justice to Franklin, however, we must remember that he followed this philosophy only until he was able financially to reject it, and when he permitted himself time to reflect—when he became more of a human being and less of a machine—his life became more useful to his fellowmen and more satisfying to himself.

Nevertheless, Franklin's philosophy filled a very definite need at the time of the publication of the *Almanac*. For those who sought a reason for being virtuous, it rationalized the acquisition of wealth and the value of time. It glorified hard work, frugality, and sobriety in an era when men, women, and children labored long hours each day, had nothing to throw away, and had too little money to waste it on trifles. It helped to spur the formation and development of the middle class in America, that stable middle class on which we depend today for the strength of industry, agriculture, and government. Further, it urged the accumulation of money to be used as capital for expansion. In our own times, we know that, without

capital, we should have no great research laboratories, no far-flung industries, no huge farms, and lacking it we would be without the resources to take economic advantage of the discoveries of science.

But why the urge to accumulate capital unless to provide stability for one's self and one's family? Down through the years, the family has been the focal point around which all else revolved. Even in primitive society, the needs and desires of the family set the pace for labor. Even primitive society had its classes and social distinctions were apparent. The parents of well-disciplined children warned them against undisciplined neighbors; to wise and sympathetic parents was accorded preferred status. Thus, the family became the cornerstone of the community, and the community prospered in proportion to the diligent labor of its component parts.

Basically the needs of the family today are the same as those in primitive times. The public wants stability and an ever-mounting standard of living; it wants protection against common hazards; it wants to be treated with dignity. In the United States, there are three social foundations which secure those needs: government, education, and industry.

Government legalizes the sanctity of the home by enacting marriage and divorce laws. It is engaged in many spheres of endeavor that were formerly reserved to private enterprise: it buys and stores surplus foods, it supports farm prices, it sends relief to areas hit by draught and storm, it supports in part school milk plans, it subsidizes air and steamship lines, it insures mortgages and savings banks deposits, it attempts to guarantee stability by undertaking public housing and slum clearance to provide decent living quarters, it assists veterans and others to purchase homes and to establish businesses, it endeavors to protect the aging with social security.

Benjamin Franklin was born into a society where the family was deeply concerned with its own traditions and where it cared for its own members. This was a matter of personal pride. Although Franklin left the family roof at an early age, he was always vitally interested in all his relatives. As a matter of fact, during his visit to England as Pennsylvania's agent in 1757, he took time to research geneological information. His correspondence with his family (especially with his favorite sister, Jane Mecom), was voluminous and his letters are filled with comforting words and advice on good housekeeping and frugality. He took continuous and active interest in the welfare of all his relatives. In the *Almanac* of 1758, Franklin wrote:

> For whom these Toils, you may perhaps enquire;
> First for *your*self, next Nature will inspire;
> The Filial Thought, fond wish, Kindred Tear
> Which makes the Parent and the Sister dear:
> To These, in closest Bands of Love ally'd,
> Their Joy and Grief you live, their Shame and Pride;
> Hence timely learn to make their Bliss your own,
> And scorn to think or act on Self alone. (15, p. 50.)

> For age and want, save while you may,
> No morning sun lasts a whole day. (15, p. 48.)

A reflective and reasonable man was Josiah Franklin, Benjamin's father, who early became conscious of the talents with which his son was endowed. Benjamin's personality charmed him; his aptitude for learning startled him; his flights of fancy frightened him. Here, indeed, was a lad who belonged to the Church, the only logical place for one who read and thought deeply. But the smell of printers' ink had tickled the nostrils of the boy and had captivated him. Where else to apprentice him, then, at the age of twelve, but with his brother James? It was a natural choice, because there were so few printers in the Colonies, but more important, there he would be under the close surveillance of his family. And so Benjamin Franklin began his career as a business man, and his rise from a lowly station to one of wealth and respect is history's domain.

Franklin never had any ideas on subsidies—he depended on his own resourcefulness, ingenuity, and thrift to build his empire.

> In things of moment, on thy self depend,
> Nor trust too far thy Servant or thy Friend:
> With private Views thy Friend may promise fair,
> And Servants very seldom prove sincere. (15, p. 16.)

If Franklin could not bring himself to rely on his friends for help, how, in his wildest dreams, could he imagine the government coming to his assistance? At the age of sixteen, he was already writing articles on good citizenship wherein he stressed the citizen's duty to cooperate in public endeavors and to work for the welfare of the community and nation. The idea, then, of securing aid from a paternalistic state was as far removed from his thoughts or desires as the atomic age. In fact, the converse was true. In his estimation, nothing could be considered wealth except that which, by making its possessor a useful citizen, brought him "weal." His own life demonstrated his convictions, for he spent the early years accumulating those funds which made it possible for him in later years to devote his entire time to government. He was the only man the struggling republic could justifiably send to Europe to secure aid, because he was a living symbol of individualism for which the republic stood. How, then, could he visualize a system built on governmental subsidy?

Franklin points out the road clearly: frugality, diligence, and industry. Every page of the *Almanac* has its reference:

> The diligent Spinner has a large Shift. (15, p. 23.)
>
> Laziness travels so slowly that Poverty soon overtakes him. (15, p. 24.)
>
> He that would rise at Court must begin by creeping. (15, p. 29.)
>
> Nor trivial Loss, nor trivial Gain despise;
> Molehills, if often heap'd, to Mountains rise;
> Weigh every small Expense, and nothing waste,
> Farthings long sav'd, amount to Pounds at last. (15, p. 17.)
>
> Scarlet, Silk and Velvet have put out the Kitchen Fire. (15, p. 31.)
>
> Get what you can, and what you get, hold;
> Tis the Stone that will turn all your Lead into Gold. (15, p. 25.)

Franklin believed in the power and majesty of the self-reliant. The common weal, he says, is best served by the efforts of every man, each at his own pace and in his own way, not by the collective efforts of many people stringently supervised by a powerful state. He was a firm believer in free trade and insisted that the self-reliant trader and his interests are sufficient to guide the direction of commerce and to fix prices. He suggested that it was contrary to the nature of trade for government to interfere in the price of commodities. Man can only live contentedly, as an individual and as part of society, on what he has; he must conserve his resources lest, like butter, they melt in the sun.

Education has aided in the stabilization of the family by opening the doors of opportunity to all citizens. With a high school education considered the recognized minimum and a college degree not uncommon in the majority of families, our nation has taken a great step forward from the days of Benjamin Franklin when formal schooling was reserved to the sons of a highly select minority. Franklin, however, like Abraham Lincoln, realized the value of learning and obtained it under great personal difficulty. "Often I sat up in my room reading the greatest part of the night, when the book was borrowed in the evening and to be returned early in the morning, lest is should be missed or wanted." (14, p. 14.)

Today, the press, radio, and television keep the public informed on world events and crucial issues, effectively increasing the store of knowledge gained in the classroom. This widespread education, however, is practicable only when a people are free, because it urges all to seek a higher place in the sun. It is impracticable to encourage this desire in a land where opportunity is limited. In our republic, opportunities for advancement still exist.

Are we then to consider that the job is done? By no means! It is education's duty honestly to demonstrate the heritage which is ours in America, assiduously to prepare our citizens for their place in a land of free enterprise, and prayerfully to bid them consider well and deeply their profound duty to preserve the traditions on which this country has been built.

But suppose a man, in Benjamin Franklin's day or our own, who has had all the formal schooling he can afford and whose family is unable to assist him financially, cannot accumulate sufficient funds to better his economic position? Where does he turn for help? Is not the government the logical place? Benjamin Franklin says, "No!" He had the answer for his times and it is the answer today. He said, "He that is known to pay punctually and exactly at the time he promises may at any time and on any occasion raise all the money his friends can spare." (1c, pp. 17–18.) Credit! In this world, as in Franklin's, where the basis of the whole industrial system is credit, it is unmistakable that credit has its foundation in character.

William Allen White says, "The United States for 150 years by the virtues in individual Americans has been able to expand commercially because, on the whole, it has been profitable to extend credit to Americans."

(1c, p. 7.) So the fact of an individual's becoming a business man does not change the character of the man—that is established during his formative years. If his character is strong and good, he will not seek credit unless he is reasonably certain that he can repay his debts. Franklin puts it even more strongly when he says, "In order to secure my credit and character as a tradesman, I took care not only to be in reality industrious and frugal, but to avoid all appearances to the contrary." (1c, p. 11.) Thus, it is man's reputation which obtains the original credit, but it is his character which assures the continued confidence of his creditors.

Industry, in opening its doors to all members of the family, has aided materially in the up-grade of standards of living in the American republic. Within the last fifty years, women have been welcomed to business and to the professions. Although Benjamin Franklin did not foresee this major change nor could he envision its consequences in the home, in the office, and in the factory, yet he did realize some of the potentialities. On April 27, 1769, he wrote Mrs. Jane Mecom from London: "The account you write of the growing industry, frugality and good sense of my countrywomen gives me more pleasure than you can imagine, for from thence I presage great advantages to our country." (1c, p. 25.)

Modern industry expends vast sums of money in research to improve its products, to seek better methods of production, and to work for the common good. Benjamin Franklin, of course, would approve this, because "people are adjusted among the different countries according to the comparative well-being of mankind." (7, p. 473.)

Great industrial and scientific developments are currently in progress, and it is possible that they will revolutionize business. There exists a close relationship between the scientific laboratory and applied research and production so that the United States will undoubtedly experience a painless but fruitful nuclear revolution in industry. Strangely, it is only recently that the possibilities of research have been recognized to any degree by top management in business, and, of course, the recent release of atomic energy for private enterprise will speed up research in many fields.

What is ahead for industry? If the rights of private enterprise without government interference are respected, we shall enter an age of practical application where the atom will be adapted to every field of human endeavor. Thus industry will make the biggest strides in the fields of chemistry, metallurgy, biology, and electronics. Human labor will be used to supervise rather than operate machines. Since mass production and its by-product, standards of living, will be infinitely increased, competition will be for markets—and here an individual's creativity and ingenuity will be taxed. The man who succeeds will have to be like Benjamin Franklin who, as Charles Franklin Kettering says, "was preeminent in making fundamental technical information and using it to develop new products and improve old ones to the benefit of everyone. . . . Today we need new products for industry to make. We need to take the discoveries out of the research

laboratories and put them into our factories to make more jobs." (1b, p. 7.)

Franklin recognized industry's duty to provide for the common good because even in his early years, he sought to supply new things to the citizens of his country. The satire he used in *Poor Richard* was a new approach to literature at a time when only religious tracts and an occasional stodgy dissertation found their way into the home. The freshness, homeliness, and appropriateness of *Poor Richard* not only brought chuckles to its readers but gave people in general a new topic of conversation. Later, when he organized the Junto, it was for the purpose of improving the educational background of his friends and to provide occasions where the free interchange of ideas would lead to mutual benefit.

So it was with his concern about fire prevention, fire protection, and fire insurance. All through his life, he harked back repeatedly to proper construction of houses—and some of his ideas are used in fire-resistive buildings today,—and fire prevention seems to have been one of the things which challenged his imagination. In a letter written at Passy to Samuel Rhoads he says, "It appears to me of great importance to build our dwelling houses, if we can, in a manner more secure from danger of fire. We scarce ever hear of a fire in Paris." (1b, p. 26.) Franklin later outlined these requirements to Mrs. Jane Mecom: "In my new buildings, I have taken a few precautions not generally used: to wit, none of the wooden work of one room communicates with the wooden work of any other room; and all the floors, and even the steps of the stairs, are plastered close to the boards, besides the plastering on the laths under the joists. There are also trap doors to go upon the roofs, that one may go out and wet the shingles in case of a neighboring fire. But indeed I think the staircase should be stone, and the floor tiles as in Paris, and the roofs either tiles or slated." (1b, p. 37.) This was, in effect, a detailed *how* for his "ounce of prevention is worth a pound of cure."

Having stressed the need for fire prevention and having suggested possible ways to deter the spread of conflagration by proper building construction, Franklin was realist enough to acknowledge that, despite all precaution, fires would occur. Imbued with that civic consciousness that characterized the greater portion of his life, he successfully launched his project of an organized and orderly fire department for Philadelphia. That enterprise well on the way to completion, Franklin turned his attention to a plan to indemnify those who suffered loss by fire. He and a group of his friends decided to raise a fund for the establishment of an insurance office "to make up the Damage that may Arise by Fire among this Company." This was the beginning of The Philadelphia Contributionship for the Insurance of Houses from Loss by Fire, America's oldest fire insurance company, founded in 1752.

Here was a venture undertaken by several men and directed to the common good. Through the pages of Franklin's newspaper, the plan was advertised to the general public and all citizens were invited to participate. It meant a pooling of resources "for the Common Security and Advantage

of our Fellow-Citizens and Neighbors . . . upon the most equal terms and apart from all Views of private or separate Gains or Interest." (17, p. 239.)

Less than two months after the first Board of Directors was elected, the Company surveyed its first risk, and America's insurance industry can trace its science of rate-making and loss prevention to that date. Early in the first year of its history, the Company developed its principle of investment in mortgages and to this day most of its income is derived from its investments. Down through the years, The Philadelphia Contributionship followed Benjamin Franklin's plan to distribute the profits, and this unique Company finds itself today one of the largest writers of perpetual insurance in America and financially stable beyond question.

Because Benjamin Franklin's personal finances were sufficiently sizable, he was able to "practice what he preached" by devoting many years of his life to the common welfare. His diplomatic service entailed a number of trips across the ocean, and on one occasion, at least, his safety was a matter of conjecture for several months.

On November 22, 1785, there appeared in *The Philadelphia Packet, and Daily Advertiser* (16) an extract of a letter written on July 18, 1785, by E. Story of London and addressed to his friend R. E. Hobart of Philadelphia. Mr. Story related that the London Packet, commanded by Captain Truxtun, was shortly due to sail from London en route to Philadelphia, with a stopover scheduled at the Isle of Thanet where Benjamin Franklin would board her. He detailed the fact that the entire cabin was in readiness for "this illustrious French-American."

Ocean voyages in those days were at best not without their terrors, so it was not unreasonable to put credence into an extract of a letter (which appeared in the newspaper on December 2, 1785) supposedly written from Algiers on August 20 by Captain Truxtun wherein he described the boarding of his ship by "piratical barbarians" and the fettering of his crew and his apprehensions for the future (21). This story, however, was discredited, for on February 10, 1786, the newspaper carried a correction and an account of Franklin's safe arrival in Philadelphia (21).

The incident, nevertheless, is not without interest, because it emphasizes the close association of Benjamin Franklin and the Philadelphia Contributionship, an unusual tie which manifests itself even today: Captain Truxtun of the London Packet was a forebear of T. Truxtun Hare who has served as a Director of the Philadelphia Contributionship since 1936.

During the course of its history, the Contributionship's affiliation with Franklin has never weakened: it has remained steadfast to the principles of free enterprise which he expounded. Its reason for being rooted in the security of the American home, the Contributionship continues to invest in industry and government whatever resources it can justifiably spare—tangible evidence of its unbounded faith in the American republic.

Is this faith warranted in the light of Franklin's principles? Yes, for today we find education providing the research that industry needs to raise the standards of living—and this in an atmosphere which government seeks

to provide for the common good. Is this the ideal state, then? No, much remains to be done, now as in Franklin's time. Through ingenuity, the individual and industry must seek to solve their problems without government assistance at every turn; through frugality, the individual, industry, and the government must conserve the nation's resources; and through diligence, the forces of the entire Republic must be marshalled to preserve those principles upon which the rights of all men depend.

REFERENCES

(1) "Profile of Genius," Edited by Nathan G. Goodman for The Franklin Institute, Philadelphia, Pa., 1938:
   (a) The Way to Wealth and Words of Wisdom from Benjamin Franklin's Poor Richard's Pamphlets.
   (b) The Practical Dr. Franklin.
   (c) Benjamin Franklin on Industry, Frugality and Thrift.
   (d) Benjamin Franklin on Honesty.
(2) "Satires and Bagatelles by Benjamin Franklin," Detroit, Fine Book Circle, 1937.
(3) "The Prefaces, Proverbs and Poems of Benjamin Franklin, originally printed in Poor Richard's Almanac for 1733–1758," collected and edited by Paul Leicester Ford, G. P. Putnam's Sons, Knickerbocker Press, 1889.
(4) "Writings of Benjamin Franklin," collected and edited by Albert Henry Smyth, Vol. X, New York, The Macmillan Company, 1907.
(5) "The Many-Sided Franklin," by Paul Leicester Ford, New York, The Century Company, 1899.
(6) "Dictionary of American Biography," Vol. VI, edited by Allen Johnson and Dumas Malone, New York, Charles Scribner's Sons, 1931.
(7) "Johns Hopkins University Series in Historical and Political Science," edited by Herbert B. Adams, Vol. XIII, Baltimore, Johns Hopkins Press, 1895.
(8) "Works of Benjamin Franklin, Including the Private as Well as the Official and Scientific Correspondence Together with the Unmutilated and Correct Version of the Autobiography," compiled and edited by John Bigelow, New York, Putnam, 1904–. Vol. III (Remarks on a Plan for the Future Management of Indian Affairs); Vol. IV; and Vol. VIII (Letter to Livingstone).
(9) "Benjamin Franklin," by Carl Van Doren, New York, Garden City Publishing Company, Inc., 1941.
(10) "The American Enterprise System," *The Baylor Bulletin*, September, 1954, Waco, (Texas), Baylor University.
(11) "The World Ahead of Us," *World's Business and Guia*, July, 1954.
(12) "Benjamin Franklin Reader," edited by Nathan G. Goodman, New York, Thomas Y. Crowell Company, 1945.
(13) "Franklin, the Apostle of Modern Times," by Bernard Fay, Boston, Little, Brown and Company, 1929.
(14) "Benjamin Franklin—The First Mr. American," by Roger Burlingame, New York, Signet Key Book, 1955.
(15) "Poor Richard's Almanack, Being the Almanacks of 1733, 1749, 1756, 1757, 1758, first written under the name of Richard Saunders by Benjamin Franklin," Garden City, N. Y., Doubleday, Doran and Company, Inc., 1928.
(16) Personal Library of T. Truxtun Hare, Director, The Philadelphia Contributionship for the Insurance of Houses from Loss by Fire, Philadelphia, Pa., U.S.A.
(17) "A Philadelphia Story: The Philadelphia Contributionship for the Insurance of Houses from Loss by Fire," by Nicholas B. Wainwright, Printed by Wm. F. Fell, Co., Philadelphia, 1952.

SCIENCE AND AGRICULTURE

BY

FIRMAN E. BEAR[1]

Philadelphia Society for Promoting Agriculture

"We are the sons of the earth and seas," wrote Benjamin Franklin, "and, like Antaeus, if in wrestling with Hercules we now and then receive a fall, a touch of our parent will communicate to us fresh strength and ability to renew the contest."

Most of the Americans of Franklin's day lived on and from the land. And Franklin himself was a farmer at heart. Although he grew to highest repute as a diplomat and statesman, his thoughts constantly returned to the soil. When he wrote: "He that by the plow would thrive Himself must either hold or drive," he was adapting farmers' philosophy to the needs of the times.

Franklin did not have time to be a real "dirt" farmer. But he carried on correspondence with the best known farmers of his day, did some experimenting on a plot of ground near Philadelphia, and imported and exported seeds and fruit and nut trees. More than this, he owned 200 acres of land in Chester County, Pennsylvania, on which he paid taxes in 1766 and afterward. The evidence suggests, however, that this land was accepted in lieu of money payment on a bad debt. In any event, the buildings and fences were in a sad state of disrepair, and the land was badly eroded and very unproductive. Yet it must be remembered that only eight of Franklin's last 33 years were spent in the United States, the management of his land being left almost entirely in the hands of his wife, Deborah, until her death in 1774.

Franklin's interest in agriculture as well as in a variety of other phases of Nature was primarily that of a scientist, in which capacity he was also well known. Robert A. Millikin was so impressed with Franklin's contributions to this field of endeavor that he classed him among the 14 most *influential* scientists who lived during the period between the birth of Copernicus in 1473 and the death of William Gibbs in 1903.

Franklin had a number of inventions to his credit, of which the lightning rod and the Franklin stove are the best known. He corresponded with the leading scientists of Europe and America, and his letters were read at the meetings of the learned societies and recorded in their minutes. He was elected to the council and chosen as a fellow of the Royal Society, London, and he was awarded honorary membership in more than a dozen other

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European and American societies for the encouragement of the arts and sciences.

When Franklin was born January 17, 1706, chemical science, as we now know it, had not come to the aid of farmers. Justus von Liebig, the "Father of Agricultural Chemistry," was not born until 1803, and his contributions to agricultural science did not come to fruition until about 1840. Yet Franklin was alert to the possibilities of applying chemical science to agriculture. In fact, he conducted an experiment with gypsum as a soil amendment a half century before Liebig's "chemical manures" had come into use.

Possibly Franklin's greatest contribution to agriculture came by way of the American Philosophical Society, which he founded in 1744. Included in the planned program of this Society was correspondence concerning "newly discovered plants, herbs, trees, and roots," methods of making them more useful, improvement of vegetable juices, particularly cider and wines, drainage of meadows, and all "philosophical experiments that let light into the nature of things, tend to increase the power of man over matter, and multiply the conveniences and pleasures of life."

It is believed that out of these phases of the Society's activities came the inspiration for organizing The Philadelphia Society for Promoting Agriculture February 11, 1785. This is the oldest and best known agricultural society in the United States. Although Franklin was not a charter member of this Society, having only recently returned from a long sojurn in Europe, he joined it on November 7 of that year.

Back of Franklin's interest in agriculture was the knowledge that the population of this country would remain largely rural for many years to come. And he pointed out that, as a result, the rate of increase in our numbers would be very rapid. Conditions in America were such as to encourage early marriages and large families. Franklin expected the population of the United States, which was less than 4 million at the time of his death, to double every 25 years. And it did just about that up to the beginning of the twentieth century, by which time our numbers had grown to over 75 million.

But Franklin, the scientist and philosopher, went much farther in his analysis of population growth than the immediate need of America required. He argued that loss of population by emigration from European countries to America would have little effect on the numbers abroad but would result in greatly increasing the population in this country. He even considered such factors as war, famine, and pestilence, effects of movement of people into cities, and postponement of marriage by reason of increase in wealth, in relation to population growth. His thoughts on these subjects antedated those of Thomas A. Malthus by half a century, and Malthus referred to them in his "Essay on the Principle of Population" in 1798.

It is this part of Franklin's and Malthus' thinking to which detailed consideration is here given. World population grew from 728 million in 1750 to 1,170 million a century later. It now stands at approximately 2,500 mil-

lion. And it is still increasing at the rate of about 1 per cent, or 25 million, a year. Over-population problems are highly troublesome among more than half of the peoples of the Earth and they may soon present themselves for very serious consideration in this country.

The population of the United States is now more than 165 million, and growing at the rate of over 2.5 million a year. During 1954 our population increase was estimated at 2.8 million. This is equivalent to a city of nearly 60,000 people in every state in the Union. And there is good reason to believe that approximately this rate of increase may continue as far as the end of the present century. Possibly we may have a population of as much as 300 million by the year 2000.

One of the most controversial topics of modern times is to whether the Malthusian principle that population tends to outgrow the food supply still applies. Certainly war, famine, pestilence, and death, the "Four Horsemen of the Apocalypse," ride rampant over a large part of the densely populated areas of the Earth. And when modern sanitary and medical measures are applied in such countries, with marked reduction in death rates, the problem becomes even more troublesome.

In a vast agricultural country such as ours it is difficult to conceive of a time when there may not be enough food to go around. Certainly the evidence to date indicates that we are a long way from starvation. In Franklin's day the capacity of farmers to feed more than their own families was quite limited. Today only about 14 per cent of our people live on farms, yet one of our most troublesome problems is crop surpluses. How far can we continue increasing our percentage of city dwellers and still be able to deliver plenty of food daily to their doors?

When Malthus published his "Essay," hunger was widespread in the over-populated parts of the Earth. Millions were starving to death every year. No means was known by which the food problem could be solved except by starvation and related population controls. Even after famine had swept across these Malthusian countries until only the strongest had survived, the number of people soon increased again to the limit set by the food supply.

Once over-population has fastened itself on a country, that country tends to become impoverished not only in material things but in spirit and mind as well. Discouragement, ignorance, and inefficiency tend to thrive. Men have little time for or inclination toward the pursuit of learning. Even when an occasional man rises above his fellows and beckons them on, his efforts on their behalf come virtually to naught. It is this fact that makes it so difficult to conceive of the older Malthusian countries rising to any very high standard of living for centuries to come.

Fortunately for the United States, science came to our aid long before any such situation could develop. Rapid growth in population was accompanied by even more rapid growth in our educational programs, in the development of the basic sciences, and in their application to the wants and

needs of man. Ours is a rich country in every sense of the word. And nothing has appeared on the horizon to date to indicate that we cannot continue permanently to enjoy the good things of life. This applies even though it is quite apparent that some tremendous problems will present themselves in due time, once all the presently available land has been put to work in crop production.

To date, most of our food production problems have been solved long before they have actually arisen. For example, development of the tractor to the present efficiency and 5-million level has relieved us of the necessity of feeding a good many times that many horses and mules. And the same applies to the millions of trucks that haul farm produce to market and manufactured goods back to the farm. Land that would otherwise have been needed to produce hay and grain for feeding work animals is now being devoted to the production of corn for feeding to poultry and livestock.

Discovery of means of producing synthetic fibers from nonagricultural raw materials released many more millions of acres from cotton production. And development of the synthetic-nitrogen industry to meet the needs of war meant greatly increased crop yields when this nitrogen was released in the peaceful art of agriculture. As a result, large acreages of land that would have been required for growing legumes for nitrogen-fixation purposes are no longer needed for such use.

Rapid advances have been and will continue to be made in the application of the sciences to crop and livestock production. Plants are being bred for cold, heat, drouth, disease, and insect resistance. Much higher yielding hybrids, such as those of corn, are on the way. Means are now available for speeding up the originating of new types of plants. A great variety of new insecticides, fungicides, and weedicides are now available for use in keeping pests under control, and many more are on the way.

Chemicals are now available for disinfecting soils on a field scale with phenomenal possibilities for increasing crop yields under many circumstances. Others are being used to root plant cuttings, prevent or cause fruit drop, depending on the need, keep sprouts from developing on stored potatoes, and stimulate more rapid growth in poultry. Cobs, cornstalks, molasses, and similar waste products are now being employed to good effect as cattle feeds, when supplemented with urea as a source of nitrogen for the protein-building microbes in the rumen.

Antibiotics have been found highly useful not only in disease control in man and animals but in plants as well. They have also been found to have considerable value in feeds. Vitamins and hormones are being employed with livestock to increase milk flow and to speed up the rate of gain in live weight. Phenomenal strides have been made in animal nutrition by which less weight of feed, when properly balanced, can be made to produce more of the product desired. Animals are being bred for increased efficiency in milk and meat production and poultry for greater egg production.

Synthetic organic chemicals have been developed for improving the physical properties of soils. These soil-conditioning substances can partially replace animal and green manures. And they are highly useful when applied over newly-planted seed in keeping the soil from forming a crust that prevents emergence of the young seedlings.

Large areas of unproductive land have been made to grow crops by applications of small quantities of trace elements, such as boron, molybdenum, copper, manganese, and zinc. The chelated forms of iron, which stay in solution in the soil and are carried unchanged into the plant, have done away with chlorosis on large acreages of crops and have materially improved acre yields even where no such chlorosis was apparent.

Phenomenal improvements have been effected in farm machinery by which manpower has been multiplied many times. And the necessary work is being done much more efficiently. The drudgery of hand labor has largely been eliminated on the farm. Crops are being harvested more rapidly and with much less waste of feed and food values. Losses in the storage and marketing of crops have been greatly reduced, and great quantities of food that once would have been wasted are now being preserved by refrigeration, drying, and canning. Mechanization has been applied not only on the farm but in the food factory as well.

Following Liebig's concepts, a tremendous soil-amendment industry has been developed by which the fertility elements long since leached out of the rocks and soil and carried out to sea are being returned to the land. Such soil-derived deposits are found in ancient seas that are now dry land. They include vast quantities of gypsum, limestone, phosphate rock, and potash salts. Added to these are ever-larger tonnages of air-nitrogen fertilizers by the use of which acre yields of most crops can be raised to more than double their present average levels.

As a result of all these developments, farmers are now harvesting crops in such abundance as to pose a very serious surplus problem. The July 1, 1955, wheat carry-over in the United States is expected to be about 1 billion bushels, enough to meet our needs for the next 18 months. Cotton carry-over of around 10 million bales is anticipated. This has occurred in spite of drastic reductions in acreages of these crops. Thus wheat allotments were cut from 79 million acres in 1953 to 62 million in 1954, and 55 million is scheduled for 1955. Similarly, cotton acreage was reduced from 27 million in 1952 to 20 million in 1954, and the expectation is that this will be reduced to 18 million in 1955.

Once the acreage allotment of a farmer for a given crop has been determined, he proceeds to employ whatever improvements in farming techniques, including much larger use of much more limestone and fertilizer, are required to maintain total production at his accustomed levels. Thus the supposedly much higher crop-producing potentialities of the land that is being farmed have been proven at a much earlier date than would otherwise have been possible.

Naturally, some disturbing doubts arise from time to time as to our capacity to continue to produce the needed food and other necessities of life in such abundance as we now enjoy. Having had so much land at our disposal, we have had a tendency to be very careless in its management. From time to time, notably following wars and during subsequent periods of extended and widespread drouths, abundant signs have indicated that all is not well on the land. An example of this is found in the tremendous dust storms that occurred in the 1930's over many millions of acres in the drier wheat regions to the West. And large acreages of once-productive cropland in the humid regions of the East and South have been abandoned because of disastrous gullying and losses of topsoil by water erosion.

It cannot be denied that, in its pioneering days, this country developed one of the most destructive systems of land use the world has ever known. Virtually all of the land east of the Mississippi River, except for the prairies of northern Illinois, was covered with forest when we took it over from the Indians. And this applies also to a large area of land in the first tier of states west of the Mississippi from Missouri southward. These trees were in the way, so our forefathers cut them down and burned them up in order to be able to put the land to the plow. The corn, potatoes, tomatoes, and tobacco of the Indians were new crops to our European ancestors. They tasted them, liked them, and quickly set about growing them. And cotton was found to be adapted to the southern states, where it soon began to flourish.

These crops are peculiar in that they are all planted in rows, with cultivation between the rows. Before anyone realized it, 140 million acres of our best land were being plowed and planted to these clean-culture crops every year. The damage to the land that soon became widely apparent grew rapidly when the fences, which had long served as Maginot lines against long sweeps of wind and water, were removed to permit of easier operation of tractors. The fertile topsoil moved ever more rapidly down hill, and it was carried away in ever greater quantities by swollen rivers that dumped it on the lowlands or into the ocean.

But it was not until the wind began sweeping vast tonnages of the soil of the abandoned wheat lands of Kansas and neighboring states across the country that the Nation at large was awakened to the seriousness of the situation. Congress, responding to the appeals of an aroused populace, passed an act establishing the Soil Conservation Service in 1935. Thanks largely to Hugh H. Bennett, pioneer American conservationist and first director of the Service, a highly constructive national program, designed to keep the soil in place, was put into operation. Millions of acres of land are now being farmed on the contour and a great variety of other conservation measures are being put into operation. Excess rain is being conserved in ponds or behind storage dams or it is being carefully carried off in sodded waterways. In the more precarious farming areas the soil is being sewed to the Earth by the roots of permanent grasses and trees.

The land area of the United States is 1,904 million acres. Of this less than one third is ever likely to be devoted to harvested crops. We are now harvesting crops from 360 million acres of our best land, under the most favorable topographic and climatic conditions. An additional 120 million acres of plowable pasture could be brought into crop production if necessary to do so. Possibly another 50 million acres could be developed for farming by clearing, irrigating, and draining. With increasing population pressure it might even be possible to expand our crop acreage to 600 million acres. But most of the remainder of the land is too dry or too rough for harvested crops. Its primary value is for grazing and forestry, or it is being used as sites for cities, military operations, parks, wildlife reservations, and transportation rights-of-way.

If water was available, large acreages of desert and range land could be brought into crop production. But where is the water for such a program to come from? We are now irrigating about 25 million acres of land, and enough water is in sight for about 25 million acres more. Most of the remainder of the arid, semi-arid, and semi-humid land will have to remain largely as such. For the most part this range land receives less than 20 inches of water a year, and a dry desert wind, with a voracious appetite for water, blows over it. Some 25 to 75 acres or more of such land is required for each grazing steer.

It is becoming more and more apparent that lack of water is by far the most seriously limiting factor in growing crops in this country, particularly at high levels of production. And this applies no matter where a farmer is located. The farther west one goes the more troublesome this problem is. But it also applies to the high-rainfall areas of the east and south, where serious summer drouths are all too common.

It is imperative that our water resources be studied to a much greater degree than has been possible as yet, and at an early date. There is need to map our underground water reserves, to study the means of storing flood waters upstream for use later, to develop aids to infiltration for adding to our underground reserves, to explore the possibilities of making it rain when and where it is needed, and to conduct much more research on how to reclaim water from the sea.

Before all this has come to pass, the decision may have been reached to reclaim large areas of land along our eastern and southern shores from the sea, as the Dutch have done. Such land is exceptionally fertile, once the extra salt has been leached out of it. But costs are high and reclamation probably will not be undertaken until population pressure has become really troublesome.

If the need actually arises, continental United States should be able to feed 1 billion—1,000 million—people, and feed them well, even with the knowledge we now possess. But they would no longer be eating the kinds and quantities of food per person we do now. They will have to be content with much less meat and milk and with much more bread, beans, and

potatoes. Animal foods are a luxury. Livestock farming constitutes a highly important means of disposing of crop surpluses. And it is a means of storing food on the hoof and in the nation's refrigerators. But in time of need, there is no economy in feeding grain to a hog or a steer and then eating these animals. At least 4 out of every 5 calories is lost by this procedure with hogs and the loss is still greater with beef cattle.

The final limiting factor in our capacity to support an ever-growing population need not be a lack of capacity to produce enough food. The important factor is energy, the kind that can be put to work on the farm and in the factory. For there are many possibilities for greater food production that remain to be explored in much greater detail. Thus it is well known that wood can be transformed into palatable feed for livestock and food for man. Potentialities for the production of yeast proteins from cellulose and other carbohydrate wastes, with supplemental use of fertilizers in tank culture, are very great. Forests have highly important possibilities as food reserves to be transformed into yeast proteins in time of need.

Yeast proteins have high food value. The people of today may not like them, but children who learned to eat them early in life might well prefer them to animal proteins. Supplemental carbohydrates, as well as proteins and fats, could readily be developed by making use of chlorella, a simple form of plant life that can be readily grown under tank culture.

Eventually, the secret of the chlorophyll molecule, by which green plants transform carbon dioxide and water into carbohydrates, may be uncovered. If and when this occurs, we may be able to produce sugar in chemical factories on a mass-production basis. And, with this as a starting point, all the other necessary proteins and fats could be manufactured by microbial agents.

Should all these happenings come to pass as a result of population pressure and the response of science to the problems arising from it, life in these United States would not have anything like its present simplicity. Producing enough food for 1 billion people would present a highly complicated problem, to say nothing of its processing and transportation to the points of need. Hopefully, population growth will be brought under control long before such conditions arise. Hopefully, it can be shown that population growth and war, or the fear of it, are not essential to national prosperity.

Our capacity to continue to meet the food needs of an expanding population is determined finally by the amount of mechanical energy at our disposal. Coal and petroleum resources are not inexhaustible. But vast amounts of energy from the desert sun are going to waste. Great reserves of water power in rivers and oceans are not being utilized. And the possibilities in the development of nuclear energy resources appear fantastic. Given abundant supplies of energy, we can do virtually anything we like.

How do these developments and related future potentialities in the application of science to the production of food and other necessities of life apply to the over-populated parts of the Earth? Careful study of this prob-

lem by capable men indicates that there is nothing to prevent their wide scale application except lack of vision and leadership on the part of those who are in control in these Malthusian countries.

The land area of the Earth is estimated at 33 billion acres, or more than 17 times that of continental United States. Of this, 3 billion acres are being cropped, and an additional 1 billion acres could be put into production at relatively low cost. The remaining 29 billion acres consist of 15 billion acres of waste land, including deserts, mountains, cities, and transportation right-of-ways, 9 billion acres of forest and woodland, and 5 billion acres of permanent pasture.

Certainly a considerable percentage of the vast acreage that is not now in crops could be brought under production with modern machinery. Weeds, insects, and diseases could be kept under control by chemicals, and the fertility of the land could be regulated by soil conservation measures and the liberal use of soil amendments. Furthermore, the potentialities of food production in the sea have not been explored.

There is good reason to believe that several times as many people as now inhabit the Earth could be well fed and clothed with the land and related resources at the World's disposal. The next half century should be a highly exciting period in which to live, as more and more effort is put into the application of science in the further development of the soil and other resources of the Earth in relation to the needs and desires of man.

"Look before, or you'll find yourself behind," said Poor Richard. And this bit of philosophy might well be applied to thought about the many problems that lie ahead if the population of the Earth continues to grow.

". . . I have lived, Sir, a long time; and the longer I live, the more convincing proofs I see of this Truth, *that* God *governs in the Affairs of Men*. And if a Sparrow cannot fall to the Ground without his Notice, is it probable that an Empire can rise without his Aid? We have been assured, Sir, in the Sacred Writings, that 'except the Lord build the House, they labour in vain that build it.' I firmly believe this; and I also believe, that, without his concurring Aid, we shall succeed in this political Building no better than the Builders of Babel; we shall be divided by our little, partial, local Interests, our Projects will be confounded, and we ourselves shall become a Reproach and a Bye-word down to future Ages. And, what is worse, Mankind may hereafter, from this unfortunate Instance, despair of establishing Government by human Wisdom, and leave it to Chance, War, and Conquest."

Motion for Prayers in the Convention
June 28, 1787

SOME ASPECTS OF FRANKLIN'S LIFE IN ENGLAND

BY

E. N. da C. ANDRADE[1]

Royal Society of Arts

One of Benjamin Franklin's great characteristics is recognized to be his passion for international co-operation. It was an ideal for which he worked passionately and, as in all matters with which he was concerned, practically, for there was never anyone less given to the flowing phrases and nebulous aspirations which characterize many well-meaning idealists. He was a warm advocate of a British Empire that should include America and, until his design for a cordial and considered co-operation was finally thwarted, worked for a fruitful understanding between the old and the new lands, then separated by so long and so hazardous a voyage.

In any estimate of causes that contributed to his broad and balanced views in science and in politics, too much importance can scarcely be placed upon his long sojourns in England. The significance of French culture and the charm of French hospitality being fully acknowledged, it must be remembered that Franklin was already over seventy, and so well past his formative period, when he took up residence in France. When he first arrived in England, however, he was a raw lad, without any experience of civilisation as known in Western Europe: the correspondence that recorded his first important scientific experiments was all with English personalities: he spent long periods of the prime of his life in this country. A brief consideration of the background of his life in England, more particularly the scientific aspects of it, may, then, be some slight contribution to an understanding of the man.

The circumstances that led to Franklin's first voyage to London are set down in his autobiography and are familiar. He arrived there in December 1724, the day before Christmas, when he was nearly nineteen years old. Philadelphia, which he had left, was at that time a town of some 10,000 inhabitants, about forty years old; London a city of some 700,000, whose history stretched back to Roman times. It was, then, a new world for the eager lad. It was, moreover, rich in interesting contrasts. Owing to the Great Fire of 1666 the centre of the city was full of new buildings, many of about the same age as the oldest buildings of Philadelphia itself. St. Paul's Cathedral had only recently been finished: Christopher Wren, whose city churches were shining white, had died the year before Franklin's

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arrival. Three hundred yards or so north of St. Paul's, however, existed ancient streets that went back centuries and it was in one of these streets that Franklin took lodgings with his companion Ralph, at three shillings and six pence per week.

Little Britain the street was called, from the fact that in earlier times the Dukes of Brittany had resided there. It was a great centre of printers and booksellers. Franklin tells us that he obtained access to an immense collection of books belonging to a bookseller Wilcox, which was in the house next door to his lodgings. A delightful account of Little Britain was written by, appropriately enough, an American, Washington Irving, nearly a hundred years later and is to be found in his *Sketch Book*. He describes how it still bore traces of a former splendour; how houses in his time ready to tumble down, and, no doubt, already dilapidated in Franklin's time, had fronts magnificently enriched with grotesque carvings on the beams. The old games of "Pope Joan" and "Tom-come-tickle-me" still survived there, he says, and sums up "Little Britain may truly be called the heart's core of the city: the strong hold of true John Bull." This was the atmosphere in which the youngster found himself, at the most impressionable time of life, and it must have had a profound influence on him.

At Palmer's printing house, close to his first lodgings, and afterwards at the larger printing-house of Watts, when he went to lodge in what is now Sardinia Street, near Lincoln's Inn Fields, he came to know intimately the London working man, but he also made other acquaintances, including the country visitors, friends of Wygate's, whom he astonished by his swimming feats in the Thames, and Sir William Wyndham, later Lord Egremont, who had heard of these feats. He met Dr. Bernard Mandeville, author of the "Fable of the Bees" to which the subtitle is "or, Private Vices Publick Benefits. Containing several Discourses, to demonstrate that Human Frailties . . . may be turn'd to the Advantage of the Civil Society," a cynical but attractive book which created a scandal in its day and went through at least ten editions in Franklin's lifetime. Franklin describes him as "a most facetious, entertaining companion." He met Dr. Henry Pemberton, who a few years later published "A View of Sir Isaac Newton's Philosophy," a popular account of Newton's work which had a great success in its day. Pemberton knew Newton well and acted as editor for the third edition of the *Principia*. He promised to give Franklin an opportunity of seeing the great man, which he never did—scarcely remarkable, as Newton was then eighty-two years old, the most famous man of his day and not particularly accessible.

He got to know Sir Hans Sloane, soon to be President of the Royal Society, who, according to the autobiography, heard of an asbestos purse which Franklin had, purchased it and showed the young man his famous collection. Asbestos was a rarity in those days. Incidentally the way in which Sloane heard of the purse was that Franklin himself had written to tell him of it: the letter still exists. Towards the end of his stay, Franklin

went about with Denham, with whom he was then associated in business, meeting tradesmen, buying articles, seeing them packed and so on. The youth, then, not only became a skilled printer, practiced in various branches of the art, but in the course of his eighteen months in London came to know characters in various walks of life, including famous men, and to see at close hand both old and new London.

The story of how, round about 1731, he came to know by correspondence Peter Collinson and how, on March 28, 1747, he sent from Philadelphia to Collinson in London the first of a series of letters describing his electrical discoveries is familiar. A great deal has been made of a passage written by Franklin in his autobiography

> One paper, which I wrote for Mr. Kinnersley, on the sameness of lightning and electricity, I sent to Dr. Michel, an acquaintance of mine and one of the members also of that [the Royal] society, who wrote me word that it had been read but was laughed at by the connoisseurs.[2]

This has been used to create the impression that the Royal Society scoffed at Franklin's earlier work. However, William Watson, in a paper read to the Royal Society on January 21st 1747–8, that is, some months only after Franklin's first letter on electricity, said

> . . . Mr. Collinson, a worthy member of this *Society*, has received a paper concerning electricity from an ingenious Gentleman, Mr. *Franklin*, a friend of his in Philadelphia. This paper, dated June 1st, 1747, I very lately perused by favour of our most worthy *President* Martin Folkes. Among other curious Remarks there is a like Solution of this Fact; for although this Gentleman's Experiment was made with a Tube instead of a Globe, the Difference is no-ways material. As this Experiment was made, and the solution thereof given upon the other Side of the *Atlantic Ocean* before this Gentleman could possibly be acquainted with ourselves having observed the same Fact here, and as he seems very conversant in this Part of Natural Philosophy, I take the liberty of laying before you his own Words.

There follows Franklin's description of the experiment in question and his explanation in terms of positive and negative electricity, words used in this connection for the first time. "The solution of this Gentlemen in relation to this *Phaenomenon*" adds Watson, "so exactly corresponds with that which I offer'd very early last Spring that I could not help communicating it." This is scarcely an ungracious reception of the work of the unknown Franklin, however Watson's claims be judged. It is, I think, the first printed record concerning Franklin's scientific work.

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[2] In the index to E. S. Scudder's *Benjamin Franklin*, there is an entry "Royal Society of London laughs at Franklin," the only entry concerning the Royal Society, followed by six page references. Three of these refer, in fact, to the way in which Franklin was honoured by the Royal Society; the only hostile one runs ". . . were received at first with a patronising sarcasm. 'Lightning identified with electricity! Really, you know, these Colonials!—Sink me, a Philadelphian—what!'" The writer's knowledge of the eighteenth century possibly owes something to the films. The earliest reference given in the Oxford Dictionary for the word "Colonial," used as an equivalent to "Colonist," is 1865.

The "Extract of a letter to Mr. P.C.,F.R.S." [Peter Collinson], printed in the *Gentleman's Magazine* for May 1750, is, perhaps, worth a word of comment. The *Gentleman's Magazine* was founded by Edward Cave, using the pseudonym Sylvanus Urban ("The Country Townsman"), in January 1731 and was an immediate success. It published matter of all kinds in which the gentry might be interested—parliamentary reports, on which Samuel Johnson was employed in his first years in London; obituary notices; records of interesting events at home and abroad; and notes on all branches of learning, antiquities, music and science. The extract is headed "A curious Remark on *Electricity;* from a Gentleman in America; whose ingenious Letters on this subject will soon be published in a separate Pamphlet, illustrated with Cuts." This publication as a separate pamphlet, rather than in the magazine which is what Collinson had in mind, was of Cave's doing. It appeared in 1751, with the title *Experiments and Observations on Electricity made at Philadelphia in America by Mr. Benjamin Franklin and Communicated in several letters to Mr. P. Collinson of London, F.R.S.* As is recounted in all lives of Franklin, it was an immediate success and established his fame. By 1774 it had gone into four editions and, as Franklin dryly remarked in his autobiography

> The papers, however, being shown to Dr. Fothergill, he thought them of too much value to be stifled, and advis'd the printing of them. Mr. Collinson then gave them to *Cave* for publication in his Gentleman's Magazine; but he chose to print them separately in a pamphlet, and Dr. Fothergill wrote the preface. Cave, it seems, judged rightly for his profit, for by the additions that arrived afterwards, they swell'd to a quarto volume, which has had five editions, and cost him nothing for copy-money.

Franklin was awarded the Copley Medal of the Royal Society, its highest honour, in 1753 and elected a Fellow of the Royal Society in 1756. Thus when Franklin arrived in London on July 27, 1757, on his famous mission to represent to the British government the views of the colonists, he came as a celebrated figure.

He had long planned to visit London, to meet old friends and new ones that he had made by correspondence, such men as Peter Collinson. He lost little time in getting in touch with the Royal Society which, throughout his life in England, was a favoured resort of his. Among its Fellows he was to number many intimate friends, including in particular William Watson. There was, further, a Society recently formed with which he was to be closely associated and that Society must now be introduced.

The Society of Arts had been somewhat loosely founded in March 1754 and was put on a more regular basis, with a president and officers, in the following year. The original expressive, but too cumbrous, title, was *The Society for the Encouragement of Arts, Manufactures and Commerce,* soon shortened to *Society of Arts,* the word *Royal* not being added until sanctioned by King Edward VII in 1908. The original object was to effect the encouragement in question by means of premiums and prizes of various

kinds: regular lectures and addresses came more than seventy years later. The building in John Adam Street, Adelphi, at present occupied by the Society, which was completed in 1774, bears on the external facade, as expressive of its purpose, the words *ARTS AND COMMERCE PROMOTED*. The main interests of the Society were the colonies, agriculture, forestry, mechanics, industrial chemistry and the fine arts.

In the year 1755 an unknown correspondent sent to the new society a copy of Franklin's "Proposal for Promoting Useful Knowledge among the British Plantations in America" [3] which at the meeting of June 18, 1755 "was read & was judg'd to be an excellent Design, if it can be put in Practice, for the Improvem't and Communication of Science amongst the British Colonys in America, and for carrying on literary Correspondences in Europe . . ." as recorded in the Minutes. This pamphlet had already been the stimulus to the foundation of the American Philosophical Society in 1744. The secretary of the Society of Arts, William Shipley, a friend of Peter Collinson, wrote to Franklin in September 1755, giving particulars of the newly founded English society. In a charming and characteristic letter, dated November 27, Franklin replied that he would be delighted to be admitted as a corresponding member and intimating that, although no subscription was demanded of correspondents, he proposed to send a sum of twenty guineas, as he in due course did. The original letter went astray and Franklin wrote again on June 15, 1756, sending a copy, which accounts for the fact that it was not until September 1 that he was elected an Honorary Corresponding Member. On the same occasion the painter, Joshua Reynolds, was elected a member: some years later, in 1768, the Royal Academy was founded, with Reynolds as the first president, which was the occasion of his knighthood.

Henry Baker, the well known microscopist, a very active Fellow of the Royal Society, and an original promoter of the Society of Arts, was delegated to write a reply to Franklin, in which, after referring in flattering terms to Franklin's "public spirit and Uncommon Abilities," he says of the Society of Arts

> Their Desire is to make Great Britain and her Colonies mutually Dear and Serviceable to each other. . . . They Detest all Narrow Minded partiality and unreasonable Jealousies, and hope the Mother Country will always protect and Cherish her Colonies with a Maternal Care and Affection, which, as far as in them lies, they shall always endeavour to promote.

Franklin's relationship with the Society was, then, most cordial even before he landed in England.

In view of the unfavourable impression produced on some American students of Franklin's life by such characters as Lord Hillsborough, it may be well to point out that the British peerage of the time included many cultivated, public-spirited and enlightened characters and that the aristocracy

[3] See Van Doren's "Life of Franklin," p. 137.

in general was well represented in both the Royal Society and the Society of Arts. The Earl of Macclesfield was President of the Royal Society at the time when Franklin was elected Fellow and remained in that office until 1764. He was a mathematician and astronomer of parts, not a mere figure head: the observatory which he set up at Shirburn, Oxfordshire, was equipped with the best instruments then existing. He was succeeded as President by the Earl of Morton, also a serious astronomer, a Scottish peer who was instrumental in founding the Philosophical—later the Royal—Society of Edinburgh. At the time when Franklin arrived there were three peers on the Council, that is, the governing body, of the Royal Society and a large number in the Fellowship—over forty in all. They were, for the most part, scarcely figures of scientific weight, but they had serious interests.

The President—and a very active President—of the Society of Arts was Lord Folkestone, who had been one of the founders, together with Lord Romney. Frequent in their attendances were Earl Stanhope and the Earls of Macclesfield, Lichfield and Verney. Sir George Savile, Franklin's advocate in the House of Commons, an aristocrat of aristocrats and very rich, was a Fellow of the Royal Society and also a hard worker on behalf of the Society of Arts. With these people, as well as with men who devoted themselves to research, with business men, with politicians of all sorts and with manufacturers and agriculturists Franklin was in intimate touch and probably as much at his ease with them as he had been with the printers in his early days.

Franklin took a great interest in the Society of Arts, as indicated by the fact that, during the three years from February 1759 to February 1762, he attended committee meetings on about fifty occasions and was often in the chair, for instance in 1761 seven times in the first eight meetings of the committee particularly concerned with colonies and trade. The subjects dealt with by this committee were largely agricultural and America was mainly concerned, so that Franklin's interest was keen and his help very real. Premiums or bounties were offered, for instance, to encourage colonial production of the dye stuffs logwood and safflower; of silk; of olive oil; and of hemp. In particular the production of potash was stimulated, in the end by offering a bounty of £4. per ton for material imported into London from America. This proved very effective and by 1768 the manufacture was well established and met English needs.[4]

It was in December 1760 that Franklin was elected chairman of the Committee of Colonies and Trade, with John Pownall as his colleague—for two chairmen were always chosen—and was re-elected in December 1761. It must not be thought that this committee, although clearly one which had very special claims on Franklin, was the only one that attracted

[4] See *Observations on the Pot-ash brought from America. With respect to its goodness, sophistication, &c. . . . The whole communicated to the Society . . . by R. Dossie: and printed, at their request, in consequence of an application made to them on these points, by the Hon. House of Representatives of the Province of Massachusetts-Bay. 1767.*

his interest and enjoyed his presence. He on several occasions attended the committees that dealt with, respectively, Polite Arts (painting and the plastic arts), Chemistry, Mechanics and Agriculture. A typical entry in the minutes of the last named committee occurs on December 1st, 1760: "Dr. Franklin gave an account of a very useful Grass which had been lately propagated through several provinces of N. America called by the Name of Timothy Grass," which is said to be the first mention of this grass in England.

After Franklin's return to America in 1762 his relations with the Society of Arts were no longer so intimate, but he continued to hold it in warm regard, as is evident from a letter which he wrote to Samuel More, the then Secretary, in 1789, two years before his death.

Turning to the Royal Society, there are no records of attendances at ordinary meetings, but Franklin was a member of Council in the four periods 1760–61, 1766–67, 1767–68 and 1772–73. He attended pretty regularly: in fact during his last period he was at practically every meeting —and there were many meetings. In this way Franklin was intimately concerned with the administration and doings of the Society. When in 1772 the Society appointed a committee to report on the protection of the powder mills at Purfleet against lightning the members were Franklin, Henry Cavendish, William Watson, John Robertson and Benjamin Wilson. This committee reported strongly in favour of Franklin's system of pointed conductor, with Wilson, always an advocate of a different system, dissenting.

In the same year, 1772, Nevil Maskelyne, the Astronomer Royal, proposed that the constant of gravitational attraction should be derived from the deflection of a plumb line by a mountain mass and the Royal Society appointed a small "Committee of Attraction," of which Franklin was a member. The ensuing investigation was the well-known Schiehallion measurement.

There was a lightning accident at Purfleet in March 1778, after war had broken out between England and America. The Royal Society committee appointed to investigate, consisting of Pringle, Watson, Cavendish, Henley, Horsley, Lane, Lord Mahon, Nairne, and Priestley, reported in favour of Franklin, then a "rebel." Lord Mahon, afterwards Earl Stanhope, published in the following year an excellent book *Principles of Electricity . . . together with An Analysis of the superior Advantages of high and pointed Conductors,* that is, Franklin's system, which was translated into French in 1781. Benjamin Wilson, advocate of blunt ends for lightning rods, took advantage of Franklin's being an official enemy to win the ear of the king. It is recorded that to certain royal representations Sir John Pringle, then the President of the Royal Society, returned the blunt reply "Sire, I cannot reverse the laws and operations of nature."

Further, when gold medals were struck in honour of James Cook, Sir Joseph Banks, as President of the Society, sent one to Franklin in 1784, accompanied by a letter, beginning

> Willing as much as in my power to clear the Royal Society and myself from our share of the charge of illiberal treatment toward you, with which I fear this country may too justly be accused, I take my pen with no small pleasure to inform you, that I am instructed by the Council of the Royal Society, to present to you, in their name, the gold medal which they have struck in honour of Captain Cook, in testimony how truly they respect those liberal sentiments which induced you, upon his return to Europe unexpected, to issue your orders to such American cruisers as were then under your direction to abstain from molesting that great navigator; an act worthy of these sentiments of general philanthropy by which I have observed your conduct ever actuated since I have had the honour of your acquaintance.

Franklin had previously received a copy of Cook's *Voyages*, sent by the king at Lord Howe's suggestion. The war, then, made no difference to the open support which Franklin's views received from the highest representatives of British science or to the respect in which he was held in exalted circles.

In considering Franklin's relations with the Royal Society, and more particularly convivial and conversational relations, it is to be noted that there was within the Society a dining club, membership of which was limited to certain selected Fellows, called the Club of the Royal Philosophers. It is still in very active existence as the Royal Society Club, to which it changed its name in 1795. The gatherings were intimate, the average attendance being at the time in question about fourteen.

We know from the records that Franklin frequently attended as a guest and that, in particular, he was there on August 11, 1757, within a fortnight of his landing. He was also present a fortnight later when the attendance, including the Earl of Macclesfield, was eleven. It may be of interest to set down the menu, a typical one for these dinners, the cost being three shillings.

Salmon & Smelts	Trout and flat fish
Fowls & Bacon	Roast beef
Goose Roast.	Pidgeon pye
Pease	Plumb pudding
Codling pye creamed	Haunch of venison.
Currant & Cherry pye	Butter & Cheese.

"The Company being entertained with a Haunch of Venison by Mr. Wray his health was drank in Claret." Whenever the company was entertained with venison, pickled salmon or suchlike gift the donor was honoured in this way.

The meeting of August 25, 1757, was a memorable one, for a petition from the Earl of Chesterfield to the King, desiring a pension and giving reasons why it should be granted to him, was read, with which the company was much entertained—in fact it made a sensation. Since it may show the aristocracy of the time in a light unfamiliar to some, and illustrate a little-known aspect of the company that Franklin kept, a few extracts are given.

> The humble Petition of Philip, Earl of Chesterfield, Knight of the Most Noble Order of the Garter, Sheweth,
>
> That your Petitioner, being rendered, by deafness, as useless and insignificant, as most of his equals and contemporaries are by nature, hopes, in common with them, to share your Majesty's Royal favour and bounty, whereby he may be enabled either to save or spend, as he shall think proper, more than he can do at present.
>
> That your Petitioner, having had the honour of serving your Majesty in several very lucrative employments, seems thereby entitled to a lucrative retreat from business and to enjoy *otium cum dignitate;* that is, leisure and a large pension.
>
> .....
>
> Your Petitioner persuades himself, that your Majesty will not suspect this his humble application to proceed from any mean, interested motive, of which he has always had the utmost abhorrence. No, Sir, he confesses his own weakness; Honour is his object; Honour is his passion; Honour is dearer to him than life. To Honour he has always sacrificed all other considerations; and upon this general principle, singly, he now solicits that honour, which in the most shining times distinguished the greatest men of Greece, who were fed at the expense of the public.
>
> Upon this Honour, so sacred to him as a Peer, so tender to him as a man, he most solemnly assures your Majesty, that, in case you should be pleased to grant him this his humble request, he will gratefully and honourably support, and promote with zeal and vigour, the worst measure that the worst Minister can ever suggest to your Majesty: but, on the other hand, should he be singled out, marked, and branded by a refusal, he thinks himself obliged in Honour to declare, that he will, to the utmost of his power, oppose the best and wisest measures that your Majesty yourself can ever dictate. . . .

From this incident Franklin will have gathered that in England corruption of public life did not pass without a polished protest in the highest circles. It may be mentioned that Chesterfield strongly disapproved of the government's attempt to tax the American colonies, and in 1765 condemned coercion with the words "For my part I never saw a froward child mended by whipping, and I would not have the mother-country become a stepmother." Perhaps it is not too fanciful to suppose that talk with Franklin may have had something to do with his attitude.

During 1758 Franklin was guest at the Club on several occasions and met, among others, the poet and physician Akenside, a frequent attender, whose "Pleasures of the Imagination" had made him famous at twenty-three. During his last long sojurn in England he was likewise a frequent guest, more especially towards the end of that period, when he had so many troubles and disasters to bear. He may well have found relaxation and comfort in that pleasant, learned, cultured and completely informal atmosphere.

If he dealt adequately with the fare provided—which is possible, for he dealt adequately with most things set before him—he must indeed have developed from his early days in London, when he was satisfied with hot water gruel and bread and butter for breakfast and with half an anchovy on a strip of bread and butter and a very little ale for supper.

In 1774 he dined twelve times with the Club, usually as the guest of

Sir John Pringle, at the time President of the Royal Society. Pringle was an intimate friend of Franklin's and supported him vigorously at the enquiry into the Purfleet lightning accident, as already mentioned. Franklin's last dinner with the Club was on January 19th, 1775, two months before he left England for good. The 19th was the day on which Parliament met, after the recess, for the fateful session that was to lead to war and the next day Chatham was to make a famous speech and to introduce Franklin into the House to hear it. He must indeed have found consolation and peace at the Club for him to have sought it at such a time. Cavendish and Joseph Banks, who was destined to succeed Pringle as President of the Royal Society, were present, as usual at this period.

These brief notes have been made on what, from a necessarily very incomplete survey of Franklin literature, would seem to be less familiar aspects of the great man's stay in England. Nothing has been said of the meeting with Priestley in 1766, so significant for the younger man, who expressed his admiration for Franklin's work in his famous *History of Electricity*, first published in 1767; nothing of the voyage to Scotland and the abiding friendships made there, nor of the honorary doctorates bestowed by St. Andrews and Oxford. These and, of course, his political duties and activities, to which he devoted such supreme qualities, have been often described.

I have been concerned to indicate the intimacy of Franklin with the more admirable aspects of British life and with some of the most worthy and distinguished of Britain's sons. Just after the end of his first sojourn he wrote to Mary Stevenson

> Of all the enviable things England has, I envy it most its people. Why should that petty Island, which, compared to America is but like a stepping stone in a brook, scarce enough of it above water to keep one's shoes dry; why, I say, should that little Island enjoy in almost every neighbourhood, more amiable, virtuous and elegant minds, than we can collect in ranging a hundred leagues of our vast forests?

It would be easy and pleasant to collect dozens of charming things that he said of the country and its people, even when incensed, as he was by the Wilkes riots. It was the best side of English life, social, political and scientific, that provided Franklin with his ideals of what world relations and, in particular, the relations between England and America, should be. We cannot conclude more fitly than with the concluding words of the letter which Franklin wrote to Josiah Quincy on September 11th 1783,

> We are now friends with England and with all mankind. May we never see another war, for in my opinion there never was a good war, or a bad peace.

THE GOOD CITIZEN OF THE WORLD

BY

B. HUBERT COOPER [1]

The Society of the Sons of St. George of Philadelphia

The weary and ill old man lay on his couch and listened. From beneath his window seemed to come the sound of marching feet.

Catholic, Protestant and Jew; white, red and black; rich, poor, and slave; English, French, German, Swede, Irish, American—all marching side by side in silent tribute to the man, Benjamin Franklin, who had done so much to make such a parade possible.

At the start of the 18th century, few believed it ever would or could be possible.

Religious persecution had not ended. Roman Catholics and Jews were still denied the right of ownership in many places. Kings, feudal-minded Lords and the Privileged Classes ruled most parts of the world. Wars were almost continuous. There was little friendship between peoples.

★ ★ ★

These facts had made a deep impression on young Benjamin Franklin while he was still in his early teens. His own family was poor. He could get only two years of formal schooling. Apprenticed to his brother, James, a newspaper publisher, his rewards were often blows and harsh criticisms.

Later, James Franklin was thrown into jail for writing critical articles about the authorities. In order to save the paper, young Ben was named publisher.

As a lad of 16, he wrote, under the name of Silence Dogood, a creed that would, some day, shake the very foundations of the 18th century world:

> I am a mortal enemy of arbitrary government and unlimited power . . . I now take up a resolution to do for the future all that lies in my way for the service of my countrymen.

FRANKLIN KEPT HIS PLEDGE

No man ever worked harder to fulfill a pledge than did Benjamin Franklin. As we look back over the past 250 years, it is almost unbelievable that anyone could have had the courage, will, patience and skill to do what he did.

Mirabeau, in his great eulogy before the National Assembly of France in 1790, said Franklin's genius "poured a flood of light over Europe . . .

[1] President, The Society of the Sons of St. George, Philadelphia, Pa., U.S.A.

and contributed most to extend . . . (the rights of man) . . . over the whole earth."

Turgot [2] said, "He snatched the lightning from the sky—and the sceptor from tyrants." Yet he did it so gracefully that five kings sought him for counsel and many of his dearest friends were among the privileged classes.

Franklin believed that the rights of every individual citizen were equal—and greater even than the State. "He taught us," Jusserand said,[3] "that no man should have a better chance in this world because he happened to be born in some certain caste or class."

HIS GREATEST ACCOMPLISHMENT

Many have written of Franklin's leadership in science; of his constructive developments in education; of his brilliance as an author, publisher, statesman and public servant.

But greater than any of these was his help in raising the dignity of every man and woman—so that all might look on the stars and dream of every worthy fulfillment.

He was no rabid revolutionist. He did not preach death and destruction to any class. "A good example is the best sermon," he wrote . . . and proceeded to prove his point by making himself the good example.

Poor, lonely and with little formal educational advantages, he arrived in Philadelphia with only one Dutch Dollar and three loaves of bread. He was 17 years old—but by the time he reached 42, had amassed a private fortune and was able to retire from business and devote the next 42 years to the fulfillment of his pledge.

This fact alone was worth more than many bloody victories. What Ben Franklin did inspired many millions of people to believe that others could do also. "Poor Richard," in his wise and homely *Almanack*, opened the door to opportunity for all, put hope, ambition and determination into the hearts of even the poorest young men and women.

GOOD CITIZEN OF THE WORLD

Equality for all races, colors, classes, castes and creeds offered the one best chance, in Franklin's opinion, for a possible end to wars and a world of peace. He wrote to David Hartley in 1789, close to the end of his life, in the wisdom of his years:

> God grant that not only the love of Liberty but a thorough knowledge of the Rights of Man may pervade all the Nations of the Earth so that a Philosopher may set his foot anywhere and say "This is my Country."

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[2] Anne Robert Jacques Turgot, Baron de l'Aulne. The statement "Eripuit caleo fulmen sceptrumque tyrannis" is attributed to Turgot by Richard E. Amacher, in his "Franklin's Wit and Folly," published by Rutgers University Press.

[3] At ceremonies held at Christ Church in Philadelphia in 1921, when Jusserand was French Ambassador to the United States.

It was through freely informing the people, Franklin believed, that kinship and trust among nations could be built. He saw little hope "to convince sovereigns of the futility of war" except through fear of reprisal. He saw much hope in raising the dignity of all individuals so that avarice, need, envy and bitterness would not make men be "wolves to one another."

Perhaps the reason why Benjamin Franklin was so convincing was because he actually "practiced what he preached." He was President of the Society for the Abolition of Slavery—and his last public act was to petition Congress to end this indignity to man. In his fight for religious tolerance, the Protestant Franklin recommended the first Roman Catholic Bishop for America; headed the list of subscribers to the Jewish Synagogue and even wrote the plan for a Church where any honest Minister of any faith might preach. The great Masonic fraternity credits him with having helped to broaden their membership from the privileged classes to men in all walks of life. His plan for the revision of the school system was to provide education for all people instead of just the privileged wealthy—even for women, a startling and shocking recommendation in his day.

THE SOCIETY OF THE SONS OF ST. GEORGE

It was this sincere belief in helping all peoples that caused Franklin to join the Society of the Sons of St. George of Philadelphia and contribute his great personal prestige to furthering its objectives. His name can be seen heading a list of new members on one of the pages of the Society's ancient minute books, now part of the famous manuscript collection of the Historical Society of Pennsylvania. The date is October 23, 1787, shortly after peace had been declared between the United States and Great Britain. Until his death he was active in the affairs of the Society. His son-in-law, Richard Bache, was one of the founding members of the Society and a number of Franklin's descendants were members.

This Society, which has its motto "I was a stranger and ye took me in" inscribed on its corporate seal, was organized in 1772 to help Englishmen who, through no fault of their own, might find themselves in need while away from their native land. For nearly two hundred years it has served the cause of international fellowship by recognizing the responsibility of individuals in one country for those from another.

One of the greatest legacies Franklin left to his countrymen and the world was emphasis on the spirit of generosity that makes one nation help the people in another when necessity arises. "What is serving God?" he wrote. "Tis doing good to man."

The billions that have been given, freely and generously, to help re-build the war-shattered economies of many countries, are perhaps, even now, helping to lay the foundations for the kind of peace Franklin dreamed could be achieved. He wrote to Edmund Burke in 1781—" . . . It certainly

becomes the wiser part (for those) who cannot prevent wars, to alleviate as much as possible the calamities attending them."

In truth, Benjamin Franklin was a Good Citizen of the World because he believed that all countries and all peoples were part of an even greater Neighborhood of Mankind. He served his own Government well—but the chief objective of his life was to serve human beings in the hope they might develop a "moral philosophy . . . that would induce and oblige nations to settle their disputes without first cutting one another's throats."

No finer tribute could be paid on this 250th Anniversary of his Birth than further definitive progress in that direction.

THE SIMPLE AND HONEST WORDS

Being a study of one of the reasons why Benjamin Franklin lives on and means more than ever, 250 years after his Birth

BY

JOHN LaCERDA [1]

Poor Richard Club of Philadelphia

Words were created to convey thoughts from one human to another. Not, as a great philosopher once said, "to hide men's thoughts."

In the beginning, words were simple, clear, honest. They had no double meanings—no intellectual snobbery—no diplomatic trickery. They expressed the desire and emotions of a simple society with powerful understanding.

But as society grew more complex, man strayed from that clear objective. He began to shape words to fit his own narrow ends. He built a scientific jargon in the mistaken belief that it created the illusion of intellect. Medical men took pride in using words that patients could not understand. Diplomacy, God help us, took even greater pride in devising a language of devious meanings. The law, not be outdone, used words to limit the force of an honest contract, so that a standing joke in our modern society is "to be sure to read the fine print."

If it be true that the curse of different languages prevented building of the Tower of Babel, then it is equally true that our own stupid misuse of words has helped to prevent a clear and warm understanding between and among peoples.

Many thoughtful men have warned against this unclear use of words. Sir Edward Salisbury, vice president of the Royal Society of London, told the 1954 graduating class at Exeter:

> Let us renounce all scientific jargon which makes us unintelligible to others, except where it gives a precision to our gropings not otherwise attainable. There is real danger that undue use of our own specialized terminology may make us feel unwarrantably superior to our fellow men and mentally isolate us.

Benjamin Franklin was a forceful advocate of simplicity and honesty in the use of words. His writings have endured for more than 200 years because they are clear and understandable to all peoples. The famous "Autobiography," according to Carl Van Doren, has been printed in more editions than any other book in America, except the Holy Bible. It is selling even now in many different languages.

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[1] President, Poor Richard Club of Philadelphia, Philadelphia, Pa., U.S.A.

The world owes an imperishable debt to Franklin for making the great science of electricity more understandable to all peoples. He scorned the creation of a scientific jargon that would make it difficult to exchange ideas and information. In his first book on the subject, "Experiments and Observations on Electricity," he used simple terms that every man could understand . . . "charge, discharge, positive, negative, conductor, non-conductor, plus, minus, condense, electrician, electrify, electric shock, battery brush, non-electric."

Almost overnight such words became intelligible even to children. They laid a firm foundation for the magnificent job of standardization on electrical terms that is one of the proud achievements of the world today. No science could have been made more forbidding than electricity. Even now, we know very little of the true nature of the "electric Fluid."

Charles Kettering once said: "It was Benjamin Franklin who first formulated the theory that electricity could exist in two states, which he called positive and negative. All of our present complex electrical equipment, from electrical power to radio, is explained by this theory."

Simple, easy-to-understand, powerful. Many believe that this simplicity is one reason why electricity is used confidently today by hundreds of millions of people who have had no scientific training at all.

It is not difficult for men to understand each other in simple terms. Who has not experienced or read of the ease with which a traveler in a strange land can make known his basic wants? It is only when he seeks a more complex level that the barriers of language and thought become increasingly difficult. In Japan, where the written language contains thousands of alphabetical characters, the educational process becomes complicated in contrast with our own alphabet of 26 letters.

Some day there may be a universal language that each nation may learn in addition to its own. The modern miracles of publishing, broadcasting, telephony, motion pictures and travel have brought that time closer than many think. Only a narrow nationalism, as stupid as the jargon of specialization, stands in the way.

Those who have seen the seven-nation television hook-up in Europe realize with dismay the unfortunate language barriers. What has not been accomplished by diplomats may be demanded by the pleasure of the people. Franklin's clear words have a meaning for that achievement, too. He wrote: "Would you persuade, speak of interest, not of reason."

Those who have promoted the idea of a universal language on the logic of reason have failed. Those who will promote it on the basis of pleasure, interest, entertainment and greater enjoyment of life will succeed. It will be such a language that all members of every family can understand. Those who make it may not come from the great halls of learning. More likely, they will be the editors, popular writers, actors and entertainers. But they will make it on the firm ground of public appeal.

Franklin fought the windy words of would-be intellectualism with flaming pen and biting humor. One of his famous "Bagatelles" was a satire on such puffery. His own creed was set down simply in a letter on the origin of "Water Sports and Whirlwinds" to John Perkins, Feb. 4, 1753:

> If my hypothesis is not the truth itself, it is at least as naked: For I have not with some of our learned moderns disguis'd my nonsense in Greek, cloth'd it in algebra or adorned it with fluxions.

How wise we would be if everyone tried for the same frank and honest expression. Words can be and must be the means of bringing the world closer together. Only by communication between peoples can there be true understanding that will end wars and advance civilization.

Modern communications have placed in the hands of all nations the machinery that could accomplish this. In a few hours, a new discovery or an idea of benefit to millions may circle the globe and spread into hundreds of millions of homes. This very fact is as startling as the first electrical fire. The truth, simple and honestly expressed, can break barriers that would defy nuclear bombs.

Franklin taught us that. The treaties he made still stand today as models of frankness and cooperation. In his own words, he said of the treaty with France:

> The great principle . . . is a perfect Equality and Reciprocity; no advantage being demanded by France, or privileges in commerce, which the states may not grant to any and every other nation.

And later he said with his deep wisdom:

> Having met with friendship from that generous nation . . . we were under ties stronger than treaties could form.

Nearly every student of Franklin agrees that much of his greatness was due to his clear and simple use of words. His papers were read in 24 of the oldest and most famous scientific societies in the world—and seldom exceeded two or three pages. Yet they helped to bring about the technological revolution.

He himself never made a speech that lasted as long as ten minutes, though he swayed empires and changed the course of history by his words.

In his immortal plea for frankness and freedom in the use of the printed word ("An Apology for Printers"), Franklin said:

> I consider the Variety of Humors among Men and despair of pleasing every Body; yet I shall not therefore leave off Printing, I shall continue my business. I shall not burn my Press and melt my Letters.

"If an *Indian* injures me, does it follow that I may revenge that Injury on all *Indians?* It is well known, that *Indians* are of different Tribes, Nations and Languages, as well as the White People. In Europe, if the *French,* who are White People, should injure the *Dutch,* are they to revenge it on the *English,* because they too are White People? The only Crime of these poor Wretches seems to have been, that they had a reddish-brown Skin, and black Hair; and some People of that Sort, it seems, had murdered some of our Relations. If it be right to kill Men for such a Reason, then, should any Man, with a freckled Face and red Hair, kill a Wife or Child of mine, it would be right for me to revenge it, by killing all the freckled red-haired Men, Women and Children, I could afterwards anywhere meet with."

A Narrative of the Late Massacres, in Lancaster County, of a Number of Indians, Friends of this Province—1764

OUR POLITICAL CRISIS—AND FAITH

BY

THE REV. ERNEST A. de BORDENAVE[1]

Christ Church

FOREWORD

"Benjamin Franklin was a religious man who practiced his religion through tolerance, unselfish service and love of his fellow-man. Since he attended Christ Church and is buried in its grounds, we hope that you, the present Rector of Christ Church, will prepare a paper on religion for our Franklin issue. The title—'Faith—the Crystallization of Our Hopes' is listed on the attached plan, but this is only a suggested title and you are free to change it at will. We visualize this paper not so much a record of Franklin's religious beliefs as a history of the changing practices of religion during the past 250 years."

This is one paragraph of the letter from the Editor of the JOURNAL OF THE FRANKLIN INSTITUTE, Dr. Henry B. Allen, inviting me to write this article and indicating its nature.

According to the invitation and, I hope, in the spirit of Benjamin Franklin, the title has been changed and the content of the paper attempts to deal with the deepest problem facing man today—himself and his political behavior.

Direct quotations, foot-notes, appendices, and bibliography have been purposely omitted in the hope that this paper may be read by others than scholars, who do not need such.

Although my indebtedness to the works of others is much greater than can be listed, it is hereby humbly and gratefully acknowledged. There is a special indebtedness to a series of lectures entitled "Christianity and the Crisis of Secularism," given by the Rev. A. T. Mollegen, S.T.M., D.D., in the Washington Cathedral Library in 1950 and '51.

It is a privilege and honor to have this participation in the 250th anniversary of Franklin's birth, especially so since I am no longer the Rector of Christ Church in Philadelphia. For this privilege and honor I thank Dr. Allen and The Franklin Institute.

E. A. DE BORDENAVE

Middleburg, Virginia
May, 1955

The political crisis of our time is the split between the so-called "free" nations and those nations that are dominated by Soviet Russia. This crisis is so acute that at best it will keep us living under the threat of war for years to come. At worst it will plunge us into an armed conflict that will threaten the survival of man's civilization, if not the existence of man himself in many parts of the world. Our thinking and writing cannot but be aimed at a resolution of this conflict, assuming a resolution is possible. If history proves a resolution not to have been possible, then our thinking and writing should have helped prepare us to stand fast when the deluge comes. This paper, therefore, has as its purpose to help us understand the crisis of our time and to help us meet it, no matter how it confronts us.

[1] Rector of Christ Church, Philadelphia, Pa., U.S.A., from 1950 to 1955.

A first thing to note about our political crisis is that the split is not between East and West. It is a split within Western civilization itself. Secondly, it is not a crisis that was created in our time, rather it roots deeply in the development of Western civilization. Its origins can be traced back two hundred and fifty years to Benjamin Franklin's time—and back further still. In fact, the political crisis with which Franklin wrestled was only one phase in the development of the crisis with which we wrestle. Our crisis began with what is commonly called the "modern period" of the West. It cannot be understood with any profoundity except as it is understood in its context of the developing modern period of Western civilization.

Therefore, our first task is to try to trace out the rise of our political crisis. Only after we have done that can we talk with relevance about "Faith" and about the relevance of "Faith" to the political crisis of our day.

The simplest way to trace this development is in terms of the major ideas that have marked the turning points. If anyone objects that ideas are too abstract a route to pursue, he needs only to be reminded of how seriously the ideas of one man, Karl Marx, have affected the life of all of us, and Marx has been dead only 73 years! Ideas furnish us as good an understanding of what has happened as can be had from any other source.

I

We must begin with the Middle Ages.

For a long time man's thinking about himself and his world had been dominated by concepts that had come into the Christian Church from Greek philosophy. These emphasized a great and unbridgeable contrast between good and evil and between the spiritual and the material. That which is good was identified with that which is spiritual. That which is evil was identified with that which is material or physical.

Since man is both spiritual and physical, hence both good and evil, he was confronted by a serious problem: how to be free from evil? This problem could be solved only by his getting away from the physical, even from the physical which was a part of himself. This would happen to him finally at death but in the meantime he was told that he could get partly away from the physical and its concomitant evil by losing himself in contemplation, meditation, prayer and other mystical practices.

Man's attitude towards the physical, material, universe was determined by this dualistic understanding of the universe. He felt that anything physical or material was his foe. It was something alien to his true being, which was good. Man felt that physical nature was his enemy, something to be escaped from or to be delivered from. His only interest in the material world was to get away from it. This attitude towards the material and physical world is always characteristic of all people whose culture is informed by a mystical religion.

In the West, however, a change had begun to take place by the beginning of the 13th century. ST. FRANCIS OF ASSISI (1182–1226) affords

us a good example of this change. The material world had ceased to be man's foe. For St. Francis all of nature was his friend; it was not to be shunned but to be courted and loved. The birds and bees, the flowers and trees, the sun and the moon—all of these were objects of St. Francis' affection.

This was a new attitude towards nature. It was the result of the Hebraic-Christian idea of Creation overcoming the Greek idea of an irreconcilable dualism. A few men began to assert that God had created all things, therefore they must be good—these include material things, which are essentially good and not evil. Nature is to be taken unto man, because it is God's nature. It is not alien to man. It is a part of God's creation and man is a part of nature and all of it is God's.

This victory of the Biblical idea of nature over the Greek idea was of the utmost importance to the development of Western civilization. No longer was it necessary for man to flee from nature; now he could turn his face towards nature. He could ask questions about it. Indeed, he *should* ask questions about it, because is was *God's* nature.

It should be noted that this was not the position of those who governed the Church at Rome. This attitude arose primarily among the Franciscans, but St. Francis had trouble with the authorities at Rome. It made no difference, however, because these new ideas were abroad in the Church and they could not be stopped.

Here was an important turning point in the development of Western civilization: when the Biblical idea of Creation emerged victorious over the Greek idea. *It was this victory of the Biblical attitude towards nature which made possible the whole development of empirical science.* It is no accident that science as we know it did not develop in any other culture. It could develop only in the West where the influence of the Hebraic-Christian attitude toward the material universe became the dominant one. This was the first turning point of Western civilization into its modern period.

II

NICHOLAS COPERNICUS (1473–1543) was a Canon of the Cathedral in Frauenburg, in East Prussia. He also practiced medicine and speculated about astronomy. He reduced his theories to writing in a treatise entitled *De revolutionibus orbium coelestium* and stated therein his conviction that the sun is the center of a great system of heavenly bodies, and the earth is only one of several planets that revolve around the sun.

This treatise was probably finished by the year 1530. But the Church officially frowned on any idea that intimated that the earth is not the center of the universe, hence Copernicus would not publish his treatise. It was not finally published until 1543 when he lay on his death-bed. Nevertheless, this new idea of Copernicus' became the foundation upon which modern astronomy has been built.

GALILEO (1564–1642) attempted to demonstrate the truth of the

theories of Copernicus and had some success. It was Galileo's persistent investigations of the laws of nature that laid the foundation for modern experimental science. Like Copernicus, Galileo was called on the carpet by the authorities of the Church at Rome. He assured those authorities that there was no intention on his part to undermine or contradict the teachings of the Church. He was confident in his own mind that truth discovered by experimental science was God's truth, which man could accept with confidence. It was truth about God's creation. So, in spite of the Church's pressure upon him to desist from his researches, Galileo continued his experimental investigations until his death.

One of the most significant results of Galileo's work was his distinguishing between those properties of matter which can be reduced to mathematical formulae and those properties which are known through the senses. He argued that the properties such as weight, volume, size, and speed of physical nature could be reduced to mathematical formulae and thus be known by man in a precise way. These facts could be discovered by patient, scientific inquiry and be known exactly. On the other hand, the taste, smell, color, sound or feel of physical objects, which are perceived through man's senses, cannot be reduced to mathematical formulae and this means that knowledge of these properties of physical nature cannot be exact knowledge. The sun, for instance, *appears* to man's sense to move across the sky each day but this could be demonstrated not to be the case.

Galileo thus created a distrust of knowledge that is known through the senses and which cannot be reduced to mathematical formulae. He also established a new kind of cleavage between the knowing subject and the known object; and he opened the way for the doubt that the knowing subject can really know the object. Thus, he opened the way for doubts and questionings about all knowledge.

Needless to say, the procedure of gaining knowledge by applying doubts and questionings was not acceptable to the Church, but it could not be stopped. The procedure of doubting and questioning was adopted as the new path to new discoveries, and it was indeed a fruitful path. The more serious the doubt and the more rigorous the questioning, the more sound the answers, it was thought.

RENÉ DESCARTES (1596–1650) was a brilliant man who breathed this atmosphere. Although he was a mathematician he was also a philosopher who applied the principle of doubt and questioning to everything. He rigorously doubted that anything existed. He wrestled with the implications of this complete doubt and concluded that he had to grant that the doubt itself existed, and if the doubt existed, then the existence of the one who doubted had to be admitted. Thus he came to his famous statement, "cogito ergo sum"—I think therefore I am.

That which is primary to all existence therefore became the human mind, the rational faculty, man's power of reason. Human reason is basic and is the bar before which all other existences must be tried. Nothing could

be accepted as having existence unless and until it so confronted human reason that it had to be accepted by that reason. God so confronts human reason, said Descartes, hence God has existence. God is to be trusted, He will not fool people. The outside world, the physical universe which appears to exist, therefore can be accepted as actually existing. So, Descartes gives us the knowing mind, God, and the physical universe, as having existence.

Here we come to the second great turning point as Western Civilization moved into its modern period and form. It occurred when Descartes made human mind, human reason, the basis of everything that exists. The human mind takes precedence over God. In fact, it decides whether or not God exists. Human reason becomes the final arbiter, the primary existence.

Although Descartes, like Galileo, had no intentions of upsetting the faith of historic Christianity, he did in fact turn it upside down and it has not yet wholly succeeded in righting itself. The God of the Hebrew-Christian faith is the ground of all being. He is the Creator and judge, the beginning and the end, of all existence. His existence makes possible man's existence and the existence of man's reason itself, which is part of man's being. Man is related to God whether he likes it or not and whether he *knows* it or not. God is Being itself.

Descartes changed all this. Man's mind became the basis of all existence. Man put his final trust in human reason and its judgment. Man's reason is trusted to determine even God's existence. Here, man's reason becomes God, in the sense that man places his final trust in it. Man's faith has a new object. It is no longer the God of the Hebrew-Christian tradition, the God who is Being itself. Man's faith is in a new God, human reason. Reason is trusted in all things and trusted ultimately.

This new kind of ultimate faith in human reason began with Descartes. Although it is thus not more than 300 years old, its influence in the succeeding centuries of Western civilization cannot be over-stated. Had one been able to have foreseen in Descartes' day how great this influence would have been, such a one could have foretold the present political split in the West, which is the crisis of our time. That split roots in Western man putting ultimate faith in human reason. One side of the split puts its ultimate faith in *collective* human reason. The other side has put its ultimate faith in *individual* human reason. In both sides, however, it is ultimate faith in something less than God, therefore both sides are putting ultimate faith in a false god. And false gods always betray those who worship them.

III

Descartes was a century ahead of Benjamin Franklin, whose life was contemporaneous with the early settlements in the American colonies. The citizens of those colonies had few books and little time for reading. They had the task of conquering the trials and hardships of a wild frontier. They

were laying foundations upon which a new society would be constructed. Not many Americans of the 17th Century ever heard of Descartes, but his influence was working itself out in Europe. It is, for instance, in the materialism of Thomas Hobbes (1588–1679) and in the reaction to him of the Cambridge Platonists. It was affecting the intellectuals of Europe even though it had little influence in America before the 18th century.

JOHN LOCKE (1632–1704) was the person of the 17th century who probably had more influence on the century of Franklin than any other one person. Locke was the apostle of "common sense." He seems to have taken the position that any problem which could not be solved by common sense was not worth worrying about.

By the use of "common sense" Locke proved the existence of God. He observed that everything that happens in nature is caused by something that preceded it and caused it. The chain of effects and their causes cannot be endless as one traces them back. There had to be a "First Cause," and this was God.

So God became the "First Cause" who set in motion the endless chains of causes and effects, and who has nothing more to do with the processes of "nature." Locke recognized that this God had disclosed Himself by revelation but this was only for the illiterate masses of men. Those whose common sense was mature, like Locke's, did not need revelation. In fact, they had to use their reason to decide whether revelation was true or not. The subject to be studied was "nature" and this would reveal to man's reason the processes begun by "nature's God."

Thus John Locke is the turning point into the 18th century when "nature" was relied on so heavily. Locke died just two years before Franklin was born.

DAVID HUME (1711–1776) took seriously the empiricism of Descartes and Locke. They had insisted that the only true knowledge of external reality was gained through empirical science and was expressable in mathematical formulae. Hume analyzed the knowledge thus gained and raised the doubt that there was any necessary correlation between the "knowledge" thus accepted by human reason and the external objects that are thus known. Hume says Descartes only proved that there is an idea of a self that experiences unknown and probably unknowable reality. Thus Hume shatters Descartes' assurance of the existence of the self, and any assurance of the existence of God and the physical world.

IMMANUEL KANT (1724–1804) was shocked by Hume's work, though he had to admit the validity of his arguments. He recognized the impossibility of arriving at knowledge through pure reason which was consciously or unconsciously presupposing the existence of a God who is knowable by man's reason. Kant said that this is not the way man knows God. Instead of knowing God by reason, Kant says that man knows God by the sense of obligation to do the right which is implanted in every man. The right is whatever a man would agree is right for every other man to do in

the same situation. Man can know what is the right and therefore it can be asserted that since man can *know* the right, he also can *do* the right. And there is implanted in every man the sense that he ought to do the right. It is this sense of "ought" where God is known. God is the author of man's sense of "ought to do the right." God is the author of man's rule of behavior and the Rewarder of the men who obey His rules.

Thus with Kant, not only does God degenerate into a giver-of-rules of conduct but Christianity itself ceases to be an intellectual matter. It is now a moral matter, a matter of enunciating rules of behavior and living by them, in the assurance that God rewards those who do this.

Locke and Kant together give us the religious atmosphere that dominated the 18th century. The God who was the "First Cause," who began the processes of nature, cannot be known by man, nor does man need to know Him. Man studies "nature," which is the resulting cause and effect sequences flowing from the First Cause. But this remote God is not absolutely indifferent to man. He makes man have a sense of ought-to-do-the-right and has somehow ordered causes and effects so that men who do the right are rewarded. It remained for man to work out his codes of conduct and live according to them. Deeds were more important than creeds.

This was the 18th century "faith" for intellectuals—and Benjamin Franklin was foremost among intellectuals!

IV

The emphasis on nature of the 18th century was spurred on by man's steadily increasing control over it. As man learned more and more of nature's secrets it seemed to open up ever new promises for man's future. Man had a profound trust in nature and in human reason's capacity to know nature and to align itself with nature's meaning and the harmonies inherent within it. "Nature" for the 18th century intellectual meant the objective universe. It was a universe that had within itself a meaning, and this meaning included a knowledge of God and of morality. Human reason applied to nature could discover, codify and obey rules of behavior sufficiently to guide men into political, economic and social organizations which in turn reflect the harmony in nature itself.

In spite of this kind of thinking, however, there were deep political splits during the 18th century. Those splits were not only between the great and powerful nations of the world; there were also splits within those nations. There were splits between those nations and their colonies and also between the colonies themselves. In short, the "harmony" so faithfully trusted had not manifested itself in political relationships.

JEAN JAQUES ROUSSEAU (1712–1778) was a French philosopher who was profoundly disturbed by the political problems of his day. He was not just a philosopher but was also a political analyst and theorist. He shared the current "faith" in human reason and nature and felt that the harmony of nature included man himself. He felt that there was within

man a "natural" friendliness that would have made for good and peaceful societies had it been able to express itself. Rousseau felt, however, that man's structures of civilization and his organizations of society had disrupted the natural harmony; that this disruption had been so complete and in effect so long that the only hope was to break, to overthrow, the social and political structures of society and to discard them. When nature was thus freed from these corrupting influences its harmonies would have a chance to express themselves. The result would be a political and economic harmony that would overcome conflict and would produce liberty and justice.

Rousseau was profoundly aware of the contradiction between the demands of individual liberty and those of order and justice. He was confident, however, that the social and political structures that distort and corrupt the harmony of nature also distort and corrupt the harmony that is within man; that if those structures are overthrown and discarded then the natural harmony within man also would express itself; that this was primarily a natural "friendliness," and this friendliness would overcome the contradictions between personal freedom and social justice.

Thus, Liberty (personal freedom), Equality (social justice) and Fraternity (man's innate spirit of friendliness) became the slogan and the hope of the French Revolution.

ADAM SMITH (1723–1790) shared Rousseau's faith in the harmony of nature and applied this faith to the economic realm. He insisted that every individual should strive for his own self-interest, that each striving would thus act as a check on other men's strivings, and the end result would be "harmony" in the economic sphere. It needed only that restrictions be removed from individual man's self-seeking to have the perfect economic order manifest itself. Smith felt that the "law of supply and demand" was a part of the economic harmony of nature and that it worked to restrain and level off the worst effects of individual self-centered actions. He knew nothing of economic situations where monopoly has gained control of "supply," nor does he indicate any concern with the fact that "demand" has to be coupled with purchasing power in order to become effective as an economic factor. But these should not be labored too strongly against Smith. He was concerned primarily to prevent the aristocratic government from using its political power to prevent the rise of the new middle class that was appearing in the Western world. His faith was in individual reason, motivated by self-interest, moving in step with the harmony in nature to produce the economic utopia. It would be a society dominated by the then rising middle class of merchants and bankers and other radicals of that day.

V

At this point it may be helpful to try to illuminate the nature of the contradiction between the demands of freedom and of order. The contradiction can be expressed in many ways: liberty *vs.* equality, or individualism

vs. justice, but it is the same problem no matter how it is expressed. It is the basic problem with which every society must wrestle.

On the one hand, people are so created that they must possess a certain measure of freedom, liberty, self-determination, individualism, if they are to be persons and not automata or lower animals. This quality is a prerequisite of human beings. No matter how regimented or how totalitarian a society may be, it has to grant a sufficient measure of this necessary quality at least to an extent that will keep the people from rebelling.

On the other hand, no society can survive unless it establishes and maintains a sufficient measure of order to enable individual persons to live together in relative peace. There have to be rules and regulations and these have to be enforced. The enforcement, however, must be administered fairly to the individuals, and the ultimate measure of fairness is that each be treated equally. This will produce justice for all the members of a society. A society has to achieve at least a sufficient measure of justice to keep the people from rebelling.

The contradiction arises from the fact that as soon as one single rule has been promulgated and enforced in the interest of order, justice and equality then the rights of freedom, individualism and self-determination have been encroached upon. And every exercise of human freedom and liberty that encroaches upon the rights and liberties and freedom of one single other person is an encroachment upon the demands of order, justice and equality. This contradiction is inevitably a part of every society, whether it be the simple unit of a family or whether it be the larger unit of nation or world.

Every society must struggle to overcome this contradiction or at least to ameliorate its worst results. Every political organization of a society promises to do these things. Every society promises to give the greatest measure of personal freedom and the best and most just order. Rousseau and Adam Smith were certain that if individual man applied his reason to the problem, the harmony of nature would be discovered and each reasonable man would bring himself into line with that harmony, thus resolving the contradiction. Rousseau thought that man's inherent "friendliness" would bridge the gap between Liberty and Equality. Smith thought that man's "sympathy"—that is, man's ability to put himself in place of the other fellow—would bridge the contradiction. Both of these now appear to have been somewhat naive.

The American Declaration of Independence, framed by a committee that included Benjamin Franklin, recognizes the contradiction. It affirms the fact that men are created equal. It affirms the fact that government is necessary to insure that individual men have the right to life and liberty and to pursuit of happiness. The Declaration, however, does not have any factor comparable to Rousseau's "Fraternity" or Smith's "Sympathy," which factor might be expected to bridge the gap between the demands that the Declaration so clearly recognized. We can assume from other writings of Thomas Jefferson that he felt that "educated" individual human reason

could be trusted to perform this function, although the Declaration itself does not indicate this.

We can be grateful that men with profounder understanding of human frailty and pridefulness wrote the Constitution of the United States. Franklin was also a member of the Constitutional Convention and it is fair to assume that he had grown in wisdom since the Declaration was written. Madison had become the stronger influence from Virginia and John Adams from the regions of New England, which regions were deeply imbued with the Reformation understanding of human nature. Thus the Constitution not only recognizes human egoism and pridefulness but it provides safeguards against the inordinate expression of these by any one branch of government. It does not eliminate the contradiction in society, but it does make possible some reconciliation of the legitimate but opposing demands of freedom and order.

VI

Every society promises freedom, liberty and personal self-determination on the one hand, and order, justice and equality on the other. This was true in both America and Europe of the 19th century. Man's advances in speculative science had been accompanied by the application of that knowledge to the controlling of nature and bringing it more and more into the service of man. The "good" society was being produced and being produced by individual man using individual reason. Liberty and justice were assured. The Industrial Revolution was moving swiftly ahead to the benefit of large segments of society. But there was another side.

KARL MARX (1818–1883) examined the results of the society that was being produced in Europe and pronounced that the procedure was not producing justice and equality, that individual men were exploiting their fellow-men to their own benefit without the exploited having a chance of enjoying the fruits produced by their labor.

Without going into the details of Marx' thoughts, it can be noted that he was a Jew and as such was familiar with the writings of the Old Testament. Also he knew Hegel's dialectical theory that Spirit expresses itself in history, that this produces its opposite and this in turn produces a synthesis of the two. Marx also knew Rousseau and his theory that it is the structures of civilization which have corrupted history and which should be overthrown so that the natural harmony could assert itself.

Marx took something from each of these sources but changed them. He said that there is the dialectic of history which Hegel had recognized but that it was not Spirit actualizing itself. Rather the dialectic was within the materialistic, physical stuff of which the universe is composed. The revolution which Rousseau called for had to be actualized by the victims of the prevailing injustice, which was the working class. The rulers of the capitalist society would surely be overthrown because of the dialectic of history but it would be the privilege of the working class, the proletariat, to

be the instrument through which this would be accomplished. This would be because this was the class that suffered from the injustice of the capitalist structure of society. When capitalism is overthrown and its forms cast off it will be succeeded by a dictatorship by the proletariat; this will rule in the new form of society where competition is eliminated; with competition gone, wars will cease because men will no longer have that acquisitiveness which is bred into them by the competitive capitalist form of society.

Working man is the vastly more numerous class of men; it is mass man. Under the dictatorship of the proletariat, mass man will apply collective reason to the solution of man's problems—will use the techniques and implements which science makes available and will bring in still another order of society; this will be a society in which there will be no classes—there will be justice and equality for all. Since there will be no acquisitive instinct among men, and hence no inclination to exploit one's fellows, then the power of the State can "wither away"—it will voluntarily evacuate.

It is true that man yields up his individual freedom, but only for a time and only to achieve an order of justice and equality and peace. When this has been attained, when the classless society has been brought into being, then the rights of individuals to personal freedom and liberty can be granted. This can be done because the individual will have become a new kind of being who can be trusted not to use his freedom and liberty to exploit his fellow man or to upset the equality and justice that will then prevail.

Two things should be noted in particular about this Marxian picture. First, it promises a society of justice, equality and peace, with finally the gift of personal freedom. Second, this society is to be achieved by applying collective human reason to the solution of man's problems, and the solution is guaranteed by the dialectic of history.

There is no final difference in the promise made by communism and the *promise* given by the free nations. There is no final difference in the *means* by which the two sides of this political split say they will use to achieve this promise. Both plan to do so by applying *human reason* to the problems of man and history. The only difference is that communism plans to apply "collective" human reason and the free nations plan to apply "individual" human reason.

The ultimate "faith" of both of these is in human reason. Both have their faith in something that is not ultimate: human reason. Not being ultimate, it is an idol, a false god. It is faith in the same false god on both sides of this political split.

Thus both sides of the political split of our time promise the same things, to be achieved by different kinds of use of human reason. For the most part there seems to be no inclination on the part of the majority of Russians to adopt the individual use of reason that the majority of Americans assume to be the best method of achieving the best society. On the other hand, there is no real evidence that the majority of the people of the United States are apt to adopt the communist method of using collective reason to achieve

this end. The political split is not acute insofar as the vast populations of the United States of America and of the United Soviet States of Russia are concerned. Each of them goes their own way without ever meeting. Each assumes that the other is evil and wrong. At least, each seems constantly to be told by press, radio and other means of communication that the other is wrong. The people seem to accept this as truth, even though the average individual in the masses of either country would perhaps be fairly inarticulate as to reasons for his conclusions.

So if the political problem of our time were only the split between the United States and Russia other people of the world could relax and let these two giants writhe in the disappointment of a stalemate. They could argue at long distance—the one insisting that the way to the "good" society is through collective reason, first binding individual reason until a society of justice and equality is achieved and then giving back to the individual person his right to be a person; the other insisting that the way to the "good" society is by maintaining and protecting the greatest measure of personal liberty, even if it temporarily precludes justice and equality, in the faith that individual human reason will eventually overcome the opposition in man and achieve these social goals.

The political split of our time, therefore, is not between a nation that has "Faith" and one that does not have "Faith." They both have "Faith" and the only difference is between "Faith-in-individual-human-reason" and "Faith-in-collective-human-reason." The object of both Faiths is the same —human reason—and it is a false god that could come into being only after Descartes.

VII

The seriousness of the split between these two sides of a false and materialistic ultimate faith in human reason is not, then, in the conflict between the peoples and the geographical units of the U.S.A. and the U.S.S.R. These giants, however, live in a finite and limited world that also includes many other peoples and geographical units. The seriousness of the split of our time arises out of the meeting of the promises and influences of the U.S.A. and the U.S.S.R. in other countries. They meet in weaker countries, in countries that are underdeveloped, in countries that have been subjected to political domination and economic exploitation by other nations, in countries that have suffered from the ravages of war, no matter whether they were on the side of the victors or the vanquished. The conflict between the two types of struggle for the "good" society, as symbolized by the secular faith of the U.S.A. and the U.S.S.R., has taken place and is taking place in these kinds of countries and it is a struggle unto death. Neither will admit defeat finally.

Yet, those of us who cherish the virtues and values of the so-called free nations would be less than candid with ourselves if we did not admit that in this struggle in these countries the U.S.S.R. has been winning since the

end of World War II. During this time the people whose lives have come under the dominance of the faith-in-collective-reason are innumerable. The nations that have been organized and are now controlled by the adherents of this faith are many. The fact is that the faith that is dominant in the U.S.S.R. has been proving more powerful than the faith that is dominant in the U.S.A.

This is the fact that should prove more disturbing to the people of the U.S.A. and of the free world than any other single fact. It should be more disturbing because communism has not been victorious due to its possessing more or better guns or ships or planes. The free nations have had more of these. The reason for the communists' successes must be sought in other than its materialistic resources. It must be sought in the realm of the spirit.

The question then becomes: Why is the communist "faith" more powerful than the faith of the free nations? The two faiths have the same object —or god—namely: human reason. So it cannot be the god they worship. Its superiority must lie in the difference in their ways of using reason. The one believes in collective reason, the other in individualistic reason. What does this mean?

It means that the communists say to people: "look at the injustice, the inequalities, the divisions that separate people—a separation that is so deep that it finally ends in war. Give up your individual liberty, your personal self-determination, and cast your lot with us in a great effort to eliminate the injustices, the inequalities, the evil and enmity from among men. Collectively we can do this. Give your life to the group for the betterment of mankind and his lot on earth. We are bound to win this effort because the thrust inherent in the material world is such that it guarantees that this end will be accomplished. You yourself can become a part of this movement of history towards its inevitable and glorious end. Even though you lose your life in the effort, your life will have had significance and meaning. That which you give your life for will be carried on to its successful conclusion by the group of which you are a member. It will collectively apply reason in the best scientific ways to the attainment of the perfect society in which there is no enmity, no classes, no strife. Your life has *ultimate* significance in the cause of communism and it has comradship *now* with kindred people who also are self-committed to this high and noble cause."

On the other hand, the secular "faith-in-individual-reason" of the free nations says to people, "the ultimate meaning of your life is to be found in the preservation and use of your personal freedom and self-determination. Your right to exercise these is threatened today by communism. You must sacrifice in order to preserve your right to use your individual reason. You may even have to sacrifice your life itself in this cause."

But that would be the end of meaning for the individual! If the ultimate meaning of my life is found in my individual reason, my personal liberty and freedom, then if I give up my life I no longer have these things—my life loses its meaning. So, instead of fighting communism and risking the

losing of my life, which would be the end of meaning for me, it would be better for me to avoid that conflict, or at least to give my life to something that will be carried on to a successful conclusion even if I die.

Although perhaps never expressed in these words, this is the choice that seems to confront people in lands where "faith-in-collective-reason" symbolized by Russia, and "faith-in-individual-reason," symbolized by the U.S.A., meet and struggle for acceptance. Faced with only these two alternatives, it should not be surprising that the faith which offers comradship now and ultimate meaning through the group exhibits a greater power to gain adherents than does the faith which offers a separated individualism whose meaning ends with death—whether that death comes in the mud of a Korea or in the wreckage of a convertible.

Unless and until the free nations have faith in a God that offers more meaning than this, and faith in a God that produces more sacrifice for the achieving of the "good society" for all men, they are doomed to continue being defeated.

VIII

Defeat for the free nations in the realm of faith and its works need not be the fateful result of the political split of our time because ultimate faith-in-individual-reason need not be the faith that determines the decisions and actions of the free nations.

The United States of America is not only the symbol of these nations but it also is the most powerful of them. And the leaders of the political life of the United States give signs of sensing the truth that faith-in-individual-reason is inadequate. There are signs that these political leaders are seeking some other and more adequate Object for their faith. Many indications of this can be cited: no political leader makes a speech without including a "nod to God"; the President not only opens his tenure of office with a prayer but he gets Baptized and joins a church; his Sunday golf is delayed until after attendance at worship; cabinet meetings are opened with prayer; members of Congress of both parties attend Bible breakfasts and discussion groups; the pledge of allegiance to the flag is altered to read "one nation *under God* etc."; the national motto "In God We Trust" is rediscovered and printed on a postage stamp; political meetings are opened with prayer; a room is set aside in the capitol building for legislators to use for meditations; and politicians are even found speaking from pulpits.

These signs in our political life can be multiplied. They have their reflections, or are themselves reflections of, a phenomenal interest in religion all across the nation. People at large seem to sense in some dark and hidden way that the faith upon which they have been depending is inadequate and they seem to be groping towards something more profound. Churches and Synagogues are being built at a faster pace than ever before in history, and they are filled with worshippers. Crowds of unprecedented sizes listen to evangelists, who speak in such improbable places as Madison Square Garden

and foot-ball stadia. "Religious" articles appear regularly in press and periodicals. "Religious" programs are popular on radio and television. "Religion" is the topic of conversation at cocktail parties and all gatherings of intellectuals. In fact, it has become "chic" to be conversant with and interested in "religion."

It is hard to assess the depth of the new faith to which these signs point, but it *may* be that this popularity of religion and its assurance that Americans have "faith" is significant for the political crisis of our time. It is doubtful, however, that its significance will be very great unless this new "faith" moves to a deeper level than is yet indicated in either its political or popular manifestations. So far, the theme song of this new development is that "Americans have faith in the future because Americans have Faith." Americans are no longer so crass as to think that other nations of the free world will follow American leadership just because Americans have greater wealth and power. Now, however, other free nations can follow America's lead because America deserves to be followed—it deserves to be followed because it has "Faith"!

What this is saying finally is that America has now put its faith in Faith. The Object of faith is no longer reason, neither individual nor collective, nor is it God—the Object of faith is *Faith*.

As naive and immature as this religious state may be, it still may represent an advance for Western man. At least it reflects a vague and uneasy awareness that there is some power beyond the power of dollars and guns, even atomic ones. It also reflects a vague and uneasy awareness that human reason is really not the ultimate God of the universe. The most respected of scientists are saying that their question "How?" will never enable them to penetrate the mysteries of the meaning of existence. Philosophers, artists and writers of prose and poetry are admitting that even though they can raise questions about the meaning of existence, the *answers* to their questions must be religious answers.

All of this means that there has been at least a partial unseating of "reason" from the throne that belongs only to Ultimate Being. Perhaps Ultimate Being has not yet been enthroned but at least some sweeping out has been done in the palace!

IX

And it may yet be that the God whose self-revelation is recorded in the Bible will move into the vacuum that has been created by faith having no Object other than itself. It may yet be that this God will move in quickly enough and with sufficient power to enable us to stand the years of pressure that can be predicted as lying ahead for us if war is averted. It may yet be that this God can give us fidelity and meaning worthy of sacrificing even life itself if war is not averted.

Even though we cannot know Him completely, He has revealed enough of Himself to us to enable us to admit that He alone is the God who is the

source of sufficient strength to give us meaning in our crisis and sufficient power to help us emerge victorious. He has revealed that He is the God who created the universe and who created man—who gave man his powers of reason. He not only gave man the power of reason but He gave man a quality of self-transcendence, a capacity to rise above the determination to which all the rest of physical nature is subject. He gave man this quality which separates man from all other animals. It is this quality that enables man to ask questions about himself and about the meaning of his existence. It is this quality that enables man to know that he is going to die.

This is the capacity that raises man above being just animal but it is also the capacity that makes man protest against the limitedness that he knows he is subjected to—the limitedness that ends with death. In the face of the fact of death, man tries to arrange for himself some kind of immortality. Since man lives in a limited world his arrangements for his own immortality are always at the expense of his fellow-man. This is where conflict arises and not from an acquired sense of acquisitiveness. Man's attempts to make arrangements for his own immortality arise out of self-love. But this same self-love is possible only because of the quality that makes man higher than all other animals.

It is this quality that enables man to know God and love—neither of which is *known* by reasoning processes only. It is this capacity given to man alone of all the animals that enables him to find a ground for his being in a relatedness of love—self-committal to—Ultimate Being.

This is the quality in man that finally is free—not determined. It is a freedom given to man that he might be man, in order that he might enjoy the relatedness of love to ultimate Being. But man uses this freedom to love himself instead—he uses it to try to create his own immortality. This creates opposition between man and man—ending in war and rumors of war. But it also creates opposition of man to God because man is making himself God. This is the human situation.

God, however, set Himself to overcome man's opposition and divisions. He set out to do this by means that would not take away from man that freedom by which he is a man. God's method was self-disclosure to man—making Himself known in ways which man could apprehend—and accept or reject.

This was the God who revealed to Moses His demand that men be free from bondage. Moses experienced a demand upon his life that he go back into Egypt and lead the children of Israel out of slavery. It was not a logical demand. Moses did not apprehend the demand through his reason only. In fact, he presented some reasonable arguments why he should *not* go back to Egypt on this errand. But the demand persisted. It was not backed up by political, economic or sociological arguments, yet Moses recognized it with his whole being. When he sought the Source of the demand he got the answer that it came from the God whose name was "I AM THAT I AM"—from the God who is self-existent, Ultimate Being,

whose very nature demanded that men be free. It was in obedience to this God and His demand that the struggle for human freedom began. It is in obedience to this God and His demand that the struggle continues.

This is the same God whose self-disclosure to man "in the fullness of time" took the form of a man. Had men been placing their faith in reason, either collective or individual, they could have measured this God-man in every way known to science and yet not have known him any more than a man can *know* the love of his wife by scientific measurements. But the men of that day were not yet rationalists. Their weakness was only that they were interested in building for themselves an immortality through obedience to religious laws. The God-man, Jesus, told them they could not do this for themselves—neither by obedience to laws nor by any other way—because death mocked their every self-centered effort. They retaliated by inflicting on him the worst death they could devise.

And he willingly bore it—loving them.

He bore the worst that they could do rather than over-rule the freedom by which they were doing it—that same freedom which makes man man. God bears the worst we can do rather than make us cease to be people. He wants men, not automata.

His bearing of the worst that men could do—his bearing it and still loving men—elicited from some men the acknowledgment that only God could love like that. This was a freely given response—and it carried with it a self-commitment to Him as the source of meaning for life, the measure of value in human affairs, and Ultimate Being in human form.

This is faith in God.

It may be that this same God—the God of Abraham, Isaac and Jacob, the God who acted for man in Christ's death and resurrection, the God whose personal influence operates in the lives of men today—it may be that He will assert Himself as the Object of the faith of Americans. It is He that can inspire us and guide us in the meeting of today's political crisis, give us humility to admit our share of guilt, give us courage to accept our share of responsibility, give us steadfastness to do what we must do and wisdom to know what that is, and give us friends who trust us as friends who are trustworthy.

A faith in the God who gives these things is essential to enable us to meet the crisis of our time. The God who would thus become the Object of our faith, to Whose ways we would commit ourselves, is the God who would rather die on a cross than to over-rule that personal, individual liberty and freedom of self-determination with which he has endowed men—that they might be men. Yet, He is also the same God who so ordered creation that man as a distinct, separated individual person cannot exist except in relationship with others. Each person has to be born into a blood-related family. Each person is born into political, economic and social structures of society and cannot help but be related to other persons in these ways and within these structures. God ordered it this way. It is He who ordained

that there be order in society, so that men might live together at all. It is He who so ordered society that justice is necessary for men to live together in peace, and so that equality is finally the standard of justice. He is the God who not only has so ordered life in this world but also He is the God who promises life beyond death to individuals only as members of a fellowship.

In faith-commitment to this God we can so value the personal that we give even our life to protect and preserve liberty and freedom. In faith-commitment to this God we are freed from the shackles and shibboleths that make us afraid to admit that we recognize the necessity of community, and can admit that we are the best *planners* and executors of social schemes aiming at justice and equality.

In faith-commitment to this God we will constantly admit and re-examine the contradiction between the demands of the personal and the demands of the social. In humility we will admit our weaknesses in resolving it and with high heart set ourselves to achieving a new measure of solutions.

Faith-commitment to this God may not enable the free nations of the world to turn the tide of communism and emerge victorious from our present political crisis. Then again, if such faith-commitment is in sufficient depth and soon enough, it may.

In either case, God is God—and man and history remain His.